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U.S. FISH & WILDLIFE SERVICE
REGION 6

ENVIRONMENTAL CONTAMINANTS PROGRAM

Characterizing Contaminant Exposure of Mountain Plovers on Wintering Grounds in California and Breeding Grounds in Colorado, Wyoming, and Montana

Photo Credit – Fritz Knopf

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Abstract

The mountain plover (*Charadrius montanus*) is a shorebird that primarily inhabits dry upland sites, such as shortgrass prairie and shrub-steppe landscapes during both wintering and breeding seasons. Nesting occurs primarily in Montana, Wyoming, Colorado, and New Mexico. The birds winter in the Central and Imperial Valleys of California as well as Arizona, Texas, and Mexico. Conversion of the mountain plovers' native grassland habitat to agricultural lands in both breeding and wintering areas has resulted in these birds using farmlands for feeding and roosting. Both the Central and Imperial Valleys report year round agriculture with over 809,400 ha (2 million acres) in production; but, these habitat preferences expose wintering mountain plovers to contaminants associated with agricultural practices, including current use pesticides and their adjuvants, persistent chemicals from historic applications, inorganic elements from irrigation drainwater, and chemicals present in the irrigation water. To evaluate the exposure of mountain plover to contaminants, we collected soil and food items at both their wintering and breeding grounds in 2006. We also collected eggs (2006-2008) to determine exposure of developing embryos to contaminants transferred by adults.

Some elevated levels of inorganic elements were found in soil and terrestrial insect food items of the mountain plover at both wintering and breeding sites but none of these was elevated in the eggs. Organic contaminants in soil and insects collected from breeding grounds were very low. However, several organic contaminants were elevated in soil and insect samples from the wintering grounds, which were also elevated in the eggs. These elevated levels of contaminants in eggs were likely the result of accumulation in adults ingesting insects and soils at the wintering grounds and then transferring them to the embryo when egg-laying occurred.

Specifically, residues of DDT (o,p' and p,p') and its metabolites DDD (o,p' and p,p') and DDE (o,p' and p,p') were detected in virtually all of the soil samples from the wintering grounds. In the Imperial Valley soils, concentrations of total DDT ranged from slightly below to more than ten-times above the Ecological Soil Screening Level of 22 ng/g dry weight (dw) for protection of avian species. Dieldrin and aldrin were also detected but were below level established for the protection of avian species. DDE was detected in all invertebrate samples, reflecting the wide-spread occurrence of DDT in general. The DDE concentration in invertebrates tended to be between 0.5 to 5.0 times the concentration in corresponding soil samples and total DDT concentrations were higher in invertebrates than the soil collected from the same location demonstrating the potential for these contaminants to bioaccumulate in the tissues of soil invertebrates, which are then ingested by mountain plover.

DDE was detected in all eggs collected from breeding sites in 2006. Concentrations ranged from 5 ng/g to 5,400 ng/g wet weight (ww) for eggs from Montana (n = 7), from 10 to 930 ng/g ww for eggs from Wyoming (n = 7), and from 11.0 - 11,500 ng/g ww for eggs from Colorado (n = 5). Furthermore, two eggs from Montana had DDE concentrations (3,000 and 5,400 ng/g ww) that were at least as high as those found to adversely affect productivity in pelicans. Two eggs from Colorado were near this concentration as well (2,700 and 2,900 ng/g ww) with an

additional egg having a concentration (11,500 ng/g ww) approaching that known to affect bald eagle reproduction.

In 2007, mountain plover eggs were collected from breeding sites in Colorado and Wyoming. All eggs had detectable levels of p,p'-DDE (range = 35 – 51,200 ng/g ww, n = 6), with the highest concentration found in an egg from Colorado. This concentration (51,200 ng/g ww) is well above the 300 ng/g shown to cause colony failure in brown pelicans and above the 16 ug/g ww level shown to cause complete nest failure in eggs of bald eagles. This egg also had detectable concentrations of o,p'-DDT, dieldrin, heptachlor epoxide, oxychlordane, and PCBs, which, if acting additively, increases the potential for adverse effects.

In 2008, eggs were collected from BLM lands, Phillips County, Montana (n = 8). DDT or one of its metabolites was detected in seven of the eight mountain plover eggs. DDE concentrations in two eggs (47,500 ng/g ww and 53,200 ng/g ww) were very high. It is possible these two eggs were not viable because of the DDE concentrations and the likelihood of either additive or synergistic effects from the other detected organochlorine residues.

Archived mountain plover eggs (n = 13) collected in 2003 were submitted for organic chemical analyses to demonstrate the presence of organic compounds and that exposure to mountain plover is ongoing. DDT was detected in three eggs and DDE was detected in all eggs with concentrations ranging from 192 ng/g dw to 292,000 ng/g dw. The egg with the highest concentration (192,000 ng/g dw or 80,000 ng/g ww) also had many other organic contaminants detected that could contribute additive toxicity to the embryo. It is unknown if this egg was viable when it was collected, but it is unlikely the egg would have hatched.

Data from this study provides information on the contaminant exposure of young-of-the-year birds (as developing embryos and as nestlings) prior to their migration to the presumed more contaminated wintering grounds. Although, we did not specifically investigate nest success or embryo survival, it is possible that the elevated levels of some organic contaminants detected would affect chick survival or cause reproductive failure. A future study investigating reproductive success is warranted to answer this question.

TABLE OF CONTENTS

Figures

Tables

Appendices

List of Acronyms and Abbreviations

Measurements

cm – centimeter
dw – dry weight
ft – foot
ha – hectare
km – kilometer
m – meter
mg/kg – milligram per kilogram
mm – millimeter
ng/g – nanogram
ppb – part per billion
ppm – part per million
μg/g – microgram per gram
μg/kg - microgram per kilogram
uL – microliter
ww – wet weight

Agencies

ATSDR – Agency for Toxic Substances and Disease Registry
BLM – Bureau of Land Management
USDOI – U.S. Department of Interior
USEPA – United State Environmental Protection Agency
USFS – U.S. Forest Service
USFWS – U.S. Fish and Wildlife Service
USGS-BRD – U.S. Geological Survey – Biological Research Division

Locations

ACF – Analytical Control Facility
ACM – Antelope Coal Mine
CMR – Charles M. Russell National Wildlife Refuge
CRWO – Carlsbad Fish and Wildlife Office
FCR – Foote Creek Rim
LMU – Lake Mason Unit
NWR – National Wildlife Refuge
PNG – Pawnee National Grassland
SBSS – Sony Bono Salton Sea
TBNG – Thunder Basin National Grassland

Chemicals and related terms

BHC – Benzene hexachloride
BW – Body Weight
DDD - dichlorodiphenyldichloroethanes

DDE – dichlorodiphenyldichloroethylenes
DDT – dichlorodiphenyltrichloroethanes
ECO-SSLs – Ecological Soil Screening Levels
HCB – Hexachlorobenzene
HCH – Hexachlorocyclohexane
ICP-MS – Inductively Coupled Plasma Emission Mass Spectrometry
LOECs – Low Observed Effect Concentration
NOAEL – No Observed Adverse Effect Level
NOEC – No Observed Effect Concentration
OCs – organochlorine compounds
OPs – Organophosphate chemicals
PCBs – Polychlorinated biphenyls
QA/QC – Quality Assurance/Quality Control
RED – Reregistration eligibility decision
TOC – Total Organic Carbon
TRV – Toxicity Reference Value

INTRODUCTION

The mountain plover (*Charadrius montanus*) is a shorebird that primarily inhabits dry upland sites, such as shortgrass prairie and shrub-steppe landscapes during both wintering and breeding seasons. This plover prefers and often breeds in black-tailed prairie dog (*Cynomys ludovicianus*) towns, especially in areas where taller grasses surround the dog town, but they will also breed in fallow fields and recently plowed ground (Knopf 1996). Nesting occurs primarily in Montana (including three different National Wildlife Refuges (NWRs), Charles M. Russell, Lake Mason, and Hailstone), Wyoming, and Colorado; although new data suggest that New Mexico may have comparable numbers. The birds winter in the Central and Imperial Valleys of California, Arizona, Texas, and Mexico (Figure 1; NatureServe 2010). Approximately half the entire United States population winters in California (Andres and Stone 2009; USFWS 2011), with the Imperial Valley becoming the increasingly favored location. Conversion of the mountain plovers' native grassland habitat to agricultural lands in both wintering and breeding areas has resulted in the birds using farmlands for feeding and roosting (Knopf and Rupert 1995), particularly in boath the Central and Imperial Valleys where over 809,400 ha (2 million acres) are in production all year. This intensive production results in increasing dependence on agricultural chemicals and potential increased exposure of mountain plovers to applied pesticides and fertilizers.

In 1982, the U.S. Fish and Wildlife Service (Service) designated the mountain plover as a category 2 candidate species, meaning that more information was necessary to determine the status of the species. In 1990, a status report suggested Federal listing under the Endangered Species Act may be warranted, and in November of 1994, the status of the mountain plover was elevated to a category 1 candidate species (USFWS 1999a). In 1999, the Service proposed to list the mountain plover as a threatened species, but in 2003, determined that the listing was not warranted (USFWS 2003a). On November 16, 2006, Forest Guardians and the Biological Conservation Alliance filed a complaint in the District Court for the Southern District of

California challenging the withdrawal of the proposal to list the mountain plover (Forest Guardians, et al. v Ken Salazar et al., Case No. 3:06-cv-02560-MMA-BLM).

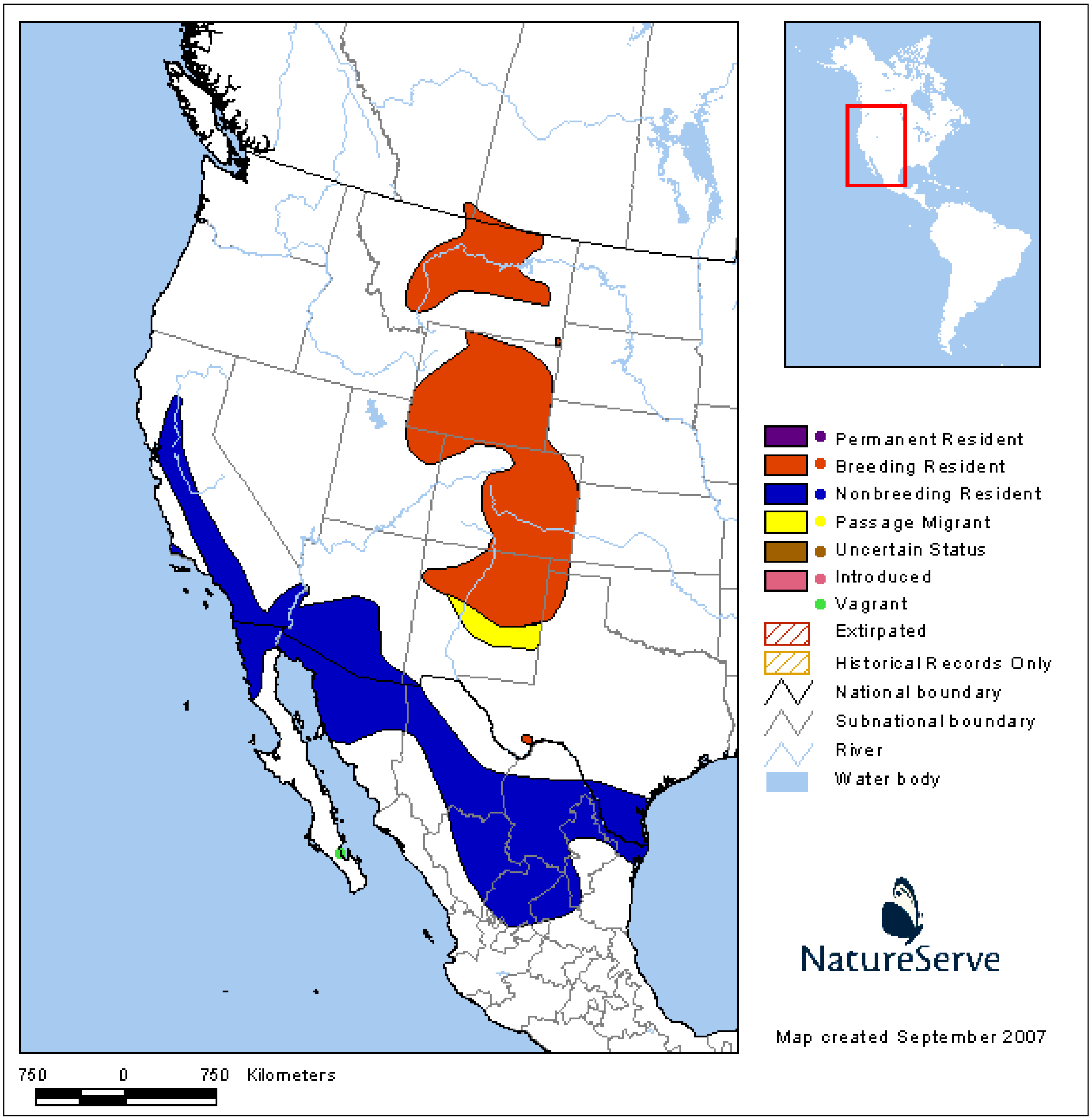

Figure 1. General location of mountain plover wintering grounds in California and breeding grounds in Montana, Wyoming, and Colorado.

A settlement agreement between the plaintiffs and the Federal defendants was filed on August 8, 2009. As part of the settlement, the Service agreed to reconsider its 2003 decision to withdraw the proposed listing of the mountain plover and to submit to the Federal Register by July 31, 2010, a notice re-opening the proposal to list the mountain plover and provide for public comment. It was agreed that upon publication of the notice, the 2003 withdrawal of the proposed rule would be vacated. After a thorough review of all available scientific and commercial information, the Service determined that the mountain plover is not threatened or endangered throughout all or a significant portion of its range as of May 12, 2011.

Although the mountain plover has never been a listed species, it is protected under the Migratory Bird Treaty Act (16 U.S.C. 703) and is on the Service's Birds of Conservation Concern list (USFWS 2008). Current mountain plover population estimates approximately 20,000 birds (USFWS 2011). Based on data from the Breeding Bird Survey, plover population declined by 67% from 1966 to 1993 (Knopf 1996) but this decline has currently moderated (USFWS 2011). Because contaminant concerns have been identified as potentially affecting the mountain plover and potentially contributing to its decline (USFWS 1999a; USFWS 2002), this investigation was designed to address this gap.

Specifically, while wintering in the Imperial Valley of California, mountain plovers spend the early winter in harvested or fallow alfalfa fields before switching over to Bermuda grass fields after the fields are burned in late winter (F. Knopf, USGS-BRD, Pers. Comm. 2/05). These habitat preferences expose wintering mountain plovers to contaminants associated with agricultural practices, including current use pesticides and their adjuvants (e.g., organophosphates and carbamate pesticides, and herbicides), persistent chemicals from historic applications (e.g., organochlorine pesticides), trace elements from irrigation drainwater (e.g., selenium), chemicals present in the irrigation water (e.g., perchlorate), and fertilizers. Although the potential for direct exposure to organophosphate and carbamate pesticides may be limited because certain applications occur when plovers are not using the fields (Wunder and Knopf 2003, USFWS 2003a), some of these pesticides (along with adjuvants and carriers) are classified as moderately persistent and residues can remain in the fields and be accumulated by wintering plovers. Numerous pesticides are applied to alfalfa and Bermuda grass fields in the Imperial

Valley that can adversely affect the long-term health of birds or their offspring. Some of these applied pesticides are known immunosuppressors in mammals (effects to birds have not been studied) and some are known endocrine disruptors.
Mountain plover exposure to environmental contaminants is not restricted to the wintering grounds. Although more limited, plovers on their breeding grounds may be exposed to insecticides used for grasshopper control, as well as DeltaDust, a synthetic pyrethroid used in some prairie dog towns to control the primary vector (fleas) of the plague bacterium *Yersinia pestis.*

To evaluate plover exposure on both wintering and breeding grounds, this study assessed (1) contaminant concentrations in likely food items consumed by mountain plovers at their wintering grounds; (2) exposure of developing embryos to contaminants transferred by adults to eggs; and, (3) contaminant levels in likely food items of nestling and adult plovers while on their breeding grounds. Data from objectives two and three will provide information on contaminant exposure by young-of-the-year birds (as developing embryos) before migrating to the presumed more contaminated wintering grounds.

METHODS

Overall, samples of soil and soil invertebrate samples were collected from five wintering locations and seven breeding areas. Presumed viable plover eggs were collected in 2006 and 2007 from breeding areas in Colorado and Wyoming and abandoned or failed-to-hatch eggs were collected in 2006 and 2008 in Montana. Additional eggs collected from Wyoming and archived in 2003 were also analyzed for contaminants as part of this study.

Study Sites

Wintering grounds

Sampling sites for wintering mountain plovers included several locations in the Imperial and Central Valleys of California (Figure 2) with one on-refuge site at the Kern NWR (K15) in the Central Valley and four sites in the Imperial Valley. Imperial Valley sites included one on-refuge field within the boundaries of the Sony Bono Salton Sea (SBSS) NWR (SB420) and three off-refuge fields nearby (J20, J22, K18). The two on-refuge sites, one on SBSS NWR (Imperial Valley) and one at Kern NWR (Central Valley) were selected based on recommendations by

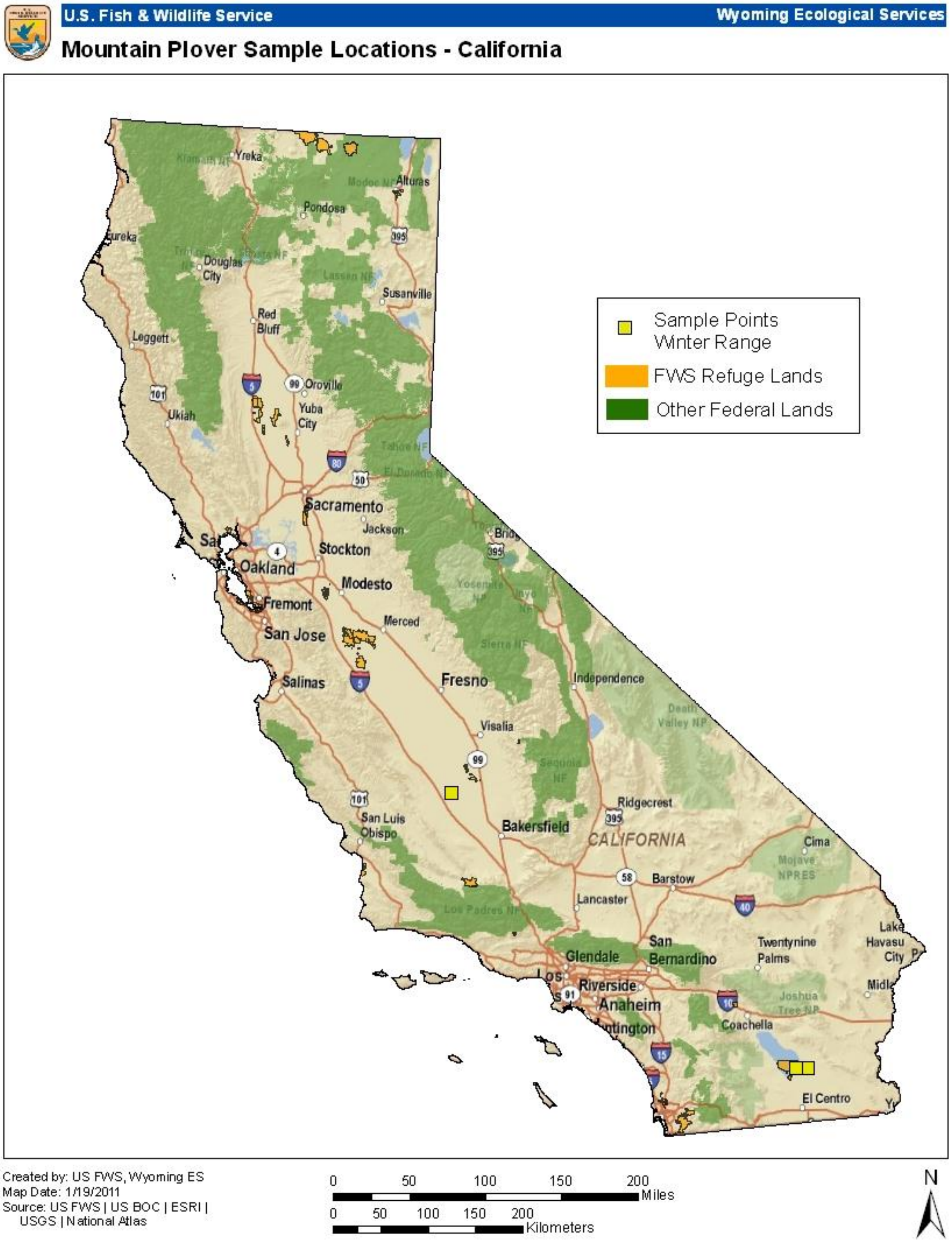

Figure 2. Sampling locations in California.

NWR managers. The three off-refuge sites in Imperial Valley were selected based on reports of where plovers were found foraging prior to spring migration and where permission to sample could be obtained from property owners and managers.

Kern NWR

Kern NWR is located in the historic Tulare Lake Basin in an area once covered by an inland lake and wetland complex totaling over 252,938 ha (625,000 acres). The refuge was established on November 18, 1960, and covers 4,297 ha (10,618 acres). It is located approximately 30.6 km (19 miles) west of the city of Delano in the San Joaquin Valley, and all of the land within the Refuge boundary is controlled by the Service. Habitats within the refuge include seasonally flooded marshes, grasslands, akali scrub/playas, and riparian lands. The refuge contains one of the few remaining wetlands left in the area and is intensively managed to produce habitat for migrating and wintering waterfowl and other waterbirds. This includes the creation of marsh conditions and other diverse habitat production to ensure the lands will provide a continuing food source for the birds (USFWS 2005).

The sampling location on Kern NWR is one of the few parcels managed for upland endangered species, primarily reptiles and small mammals, but it also may attract mountain plovers (Figure 3). Vegetation in the field that was sampled included mixed grasses, with patches of scrub such as iodine bush (*Allenrolfea occidentalis*), suaeda (*Suaeda* sp.), and alkali heath (*Frankenia salina*). According to refuge management, the field had not been farmed for many years with grazing used to control non-native grasses. Pixley NWR, established on November 17, 1959, is located approximately 30.6 km (19 miles) south of the city of Tulare in the San Joaquin Valley. The NWR is located within the Tulare Basin, of which Tulare Lake is the lowest portion. This refuge has agricultural fields with annual grasses that are used by mountain plovers, but the site could not be sampled due to concerns about potential impacts on the federally endangered blunt-nosed leopard lizard (*Gambelia silus*).

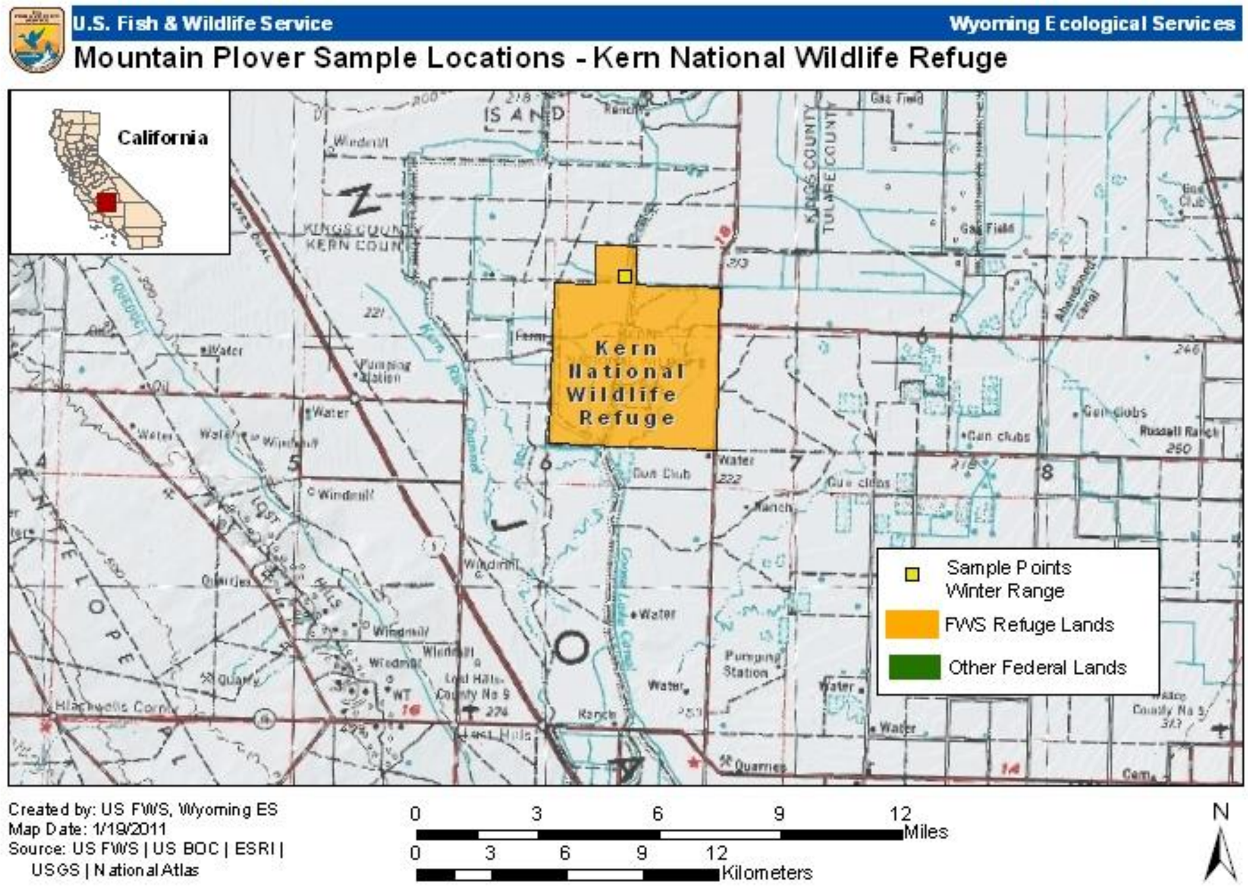

Figure 3. Kern National Wildlife Refuge sampling location.

Sonny Bono NWR

The on-refuge site in Imperial Valley was near the off-refuge sample sites but within the boundaries of the SBSS NWR (Figure 4). Mountain plovers were not reported present on refuge lands, but the field selected by the Refuge Manager is managed in a way that may attract plovers in the future. Specifically, the field was used to cultivate rye grass (*Lolium* sp.), which is then grazed by cows. Rye grass is the preferred crop because it requires much less pesticide use than Bermuda grass. According to the Refuge Manager, this field has been treated occasionally with a dicamba formulation to control invasive plant species.

Imperial Valley – Off-Refuge Fields

The three off-refuge sites in the Imperial Valley were selected based on reports of where plovers were found to forage prior to spring migration and where permission to sample could be obtained from property owners and managers (Figure 4).

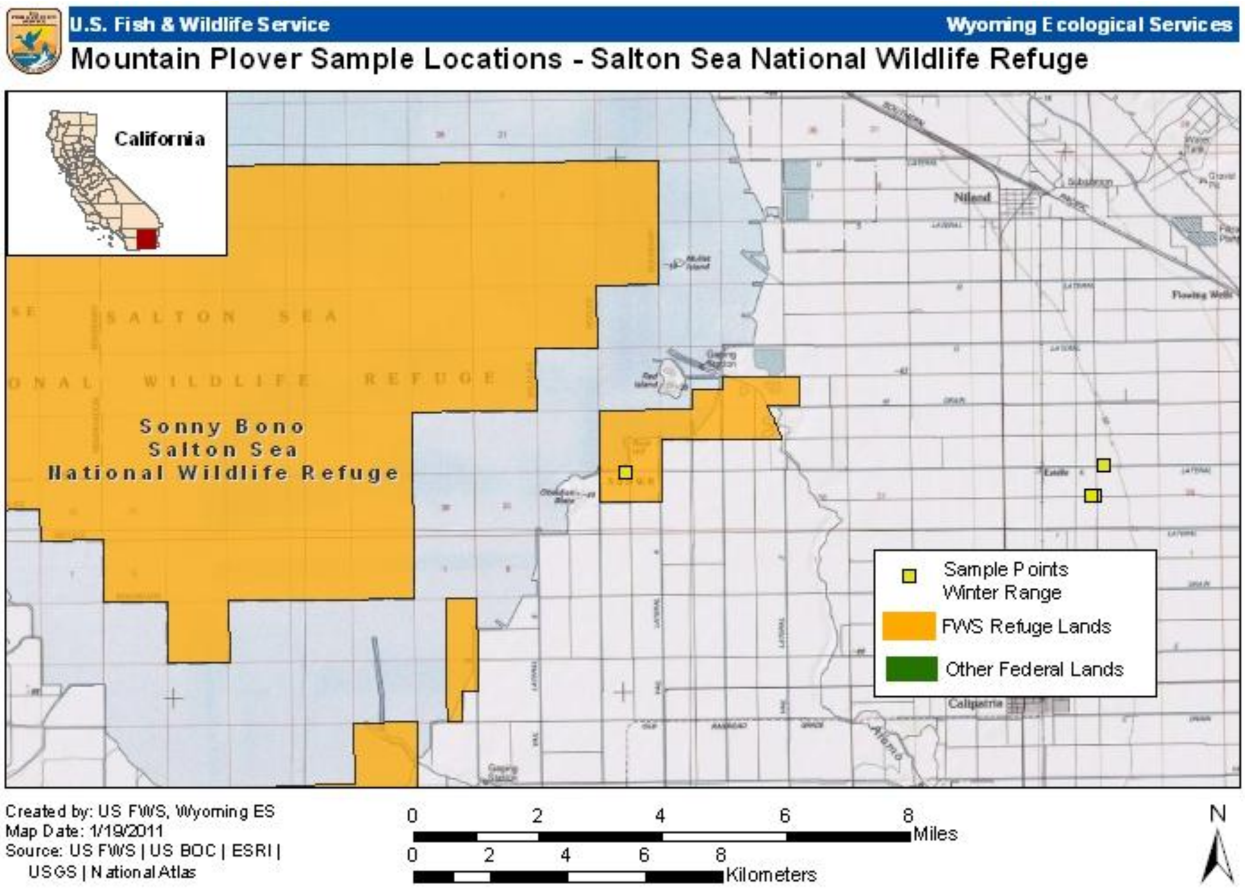

Figure 4. SBSS NWR and Imperial Valley sample locations.

The three off-refuge sites (J20, J22, and K18) were active agricultural fields. All three fields were subjected to post-harvest burns prior to use by the plovers. Between March, when the plovers left, and the first of May, when samples were taken, the fields were tilled and grasses had re-grown to a height of approximately 15.2 cm. Records of pesticide use for individual fields were not readily available. However, two fields (J20 and J22) were replanted with Bermuda grass, assumed to have been treated with the fumigants (e.g. sulfur) and pesticides typically employed for Bermuda grass crops in Imperial Valley (Pesticide Action Network 2010). The third agricultural field (K18) had a mix of grasses indicating that it may have gone fallow that season. As such, K18 may not have been treated with products used for Bermuda grass cultivation prior to sampling.

Breeding Grounds

Several known breeding grounds in Montana, Wyoming, and Colorado were selected as study sites. This included public lands administered by the Bureau of Land Management (BLM), U.S. Forest Service (USFS), and the Service's NWR system.

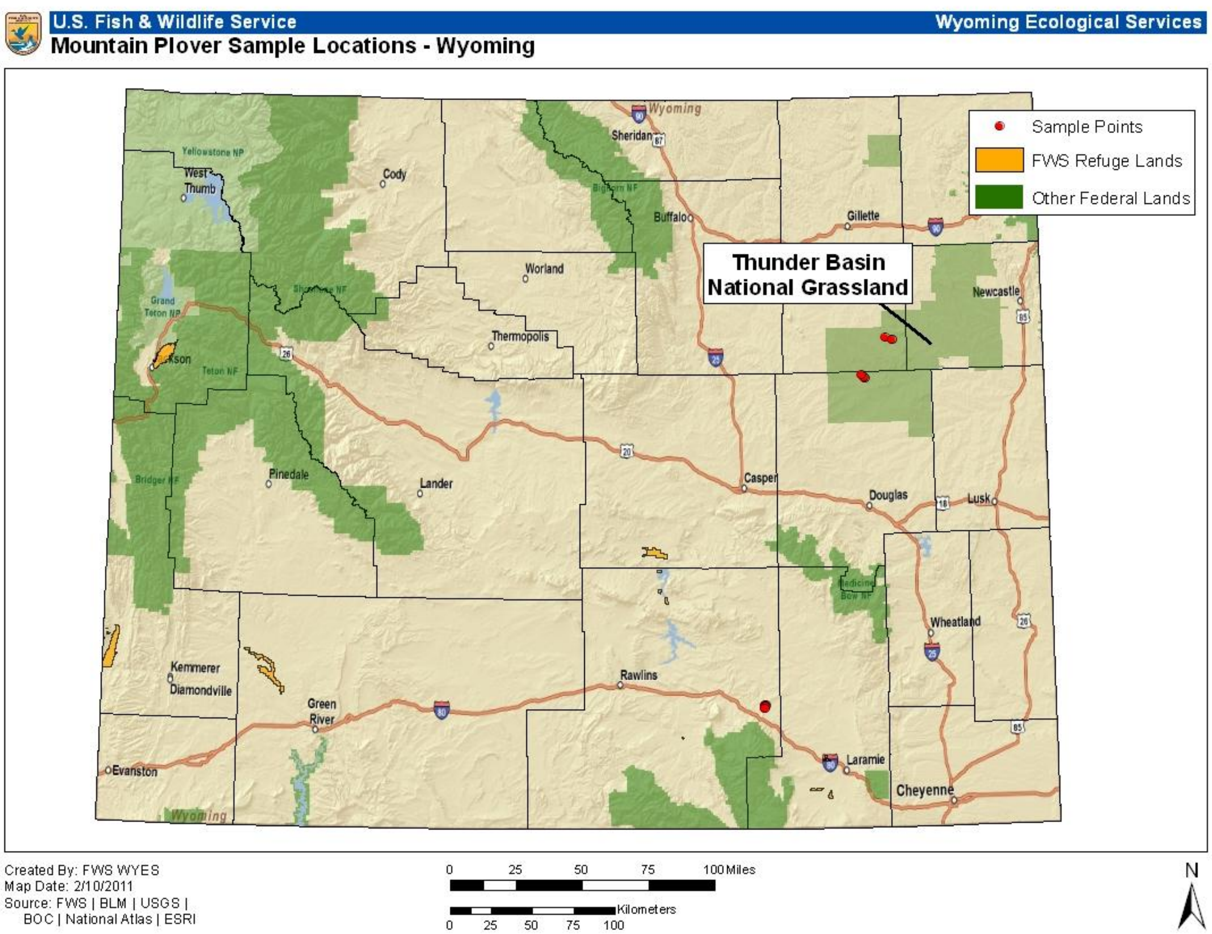

Figure 5. Sampling locations in Wyoming.

Wyoming

Study sites in Wyoming included the Thunder Basin National Grassland (TBNG) with an adjacent area near the Antelope Coal Mine (ACM) and Foote Creek Rim (FCR) in souther Wyoming (Figure 5).

TBNG, managed by the Douglas Ranger District of the USFS, is located in northeastern Wyoming in the Powder River Basin with the Big Horn Mountains to the west and the Black Hills to the east (Figure 6). The area consists primarily of shortgrass prairie and sagebrush, which provides habitat for white-tailed deer (*Odocoileus virginianus*), mule deer (*Odocoileus hemionus*), pronghorn antelope (*Antilocapra americana*), numerous small mammals, and a variety of raptors and songbirds (USFS 2010).

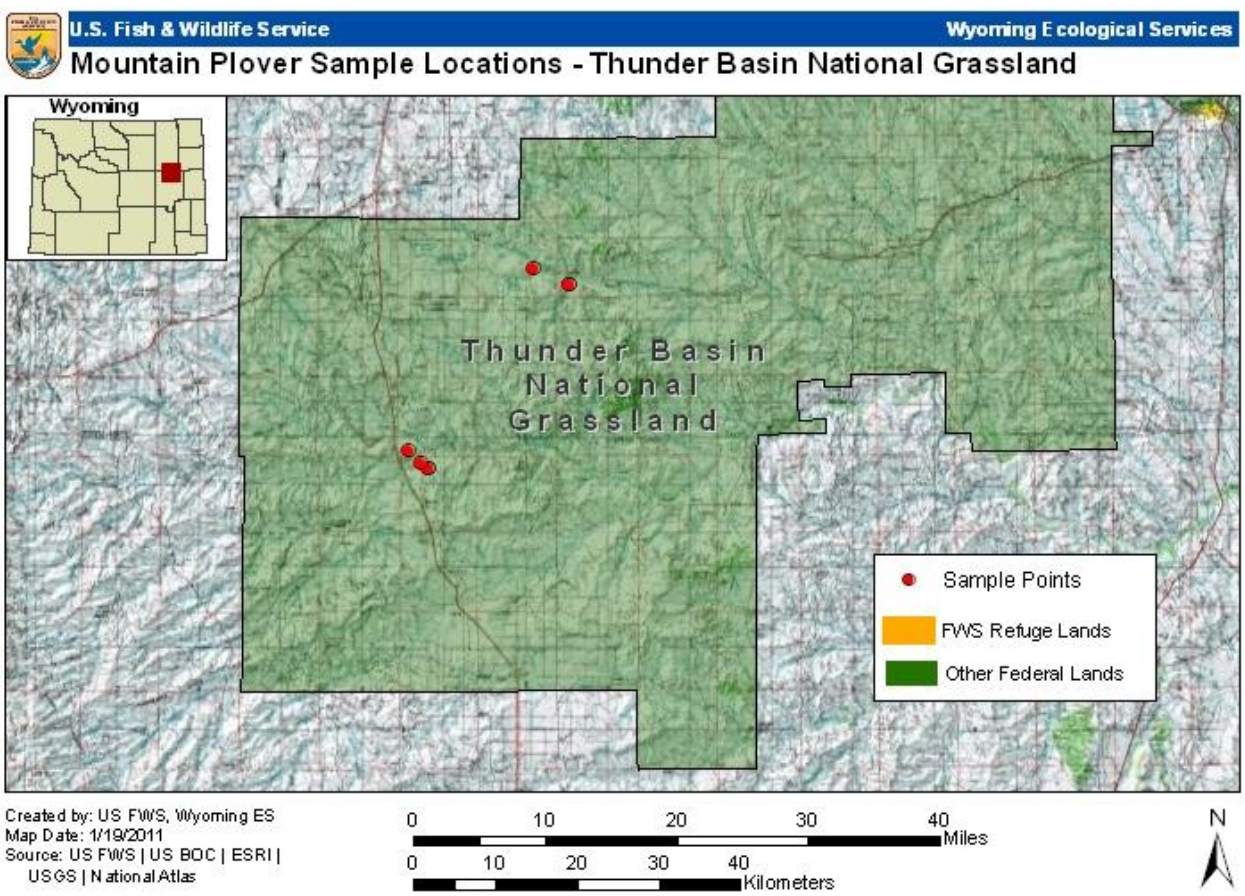

Figure 6. Thunder Basin National Grassland sampling locations.

An additional breeding area, located on Foote Creek Rim (FCR) near the Arlington Wind Plant in southeastern Wyoming was also selected as a study area (Figure 7). FCR is a remote, treeless plateau consisting of shortgrass prairie. Located between the towns of Laramie and Rawlins, the area is considered one of the windiest places in America. It is important habitat for white-tailed deer, mule deer, pronghorn antelope, elk (*Cervus elaphus*), and numerous species of small mammals, raptors, and passerines (BLM 2010).

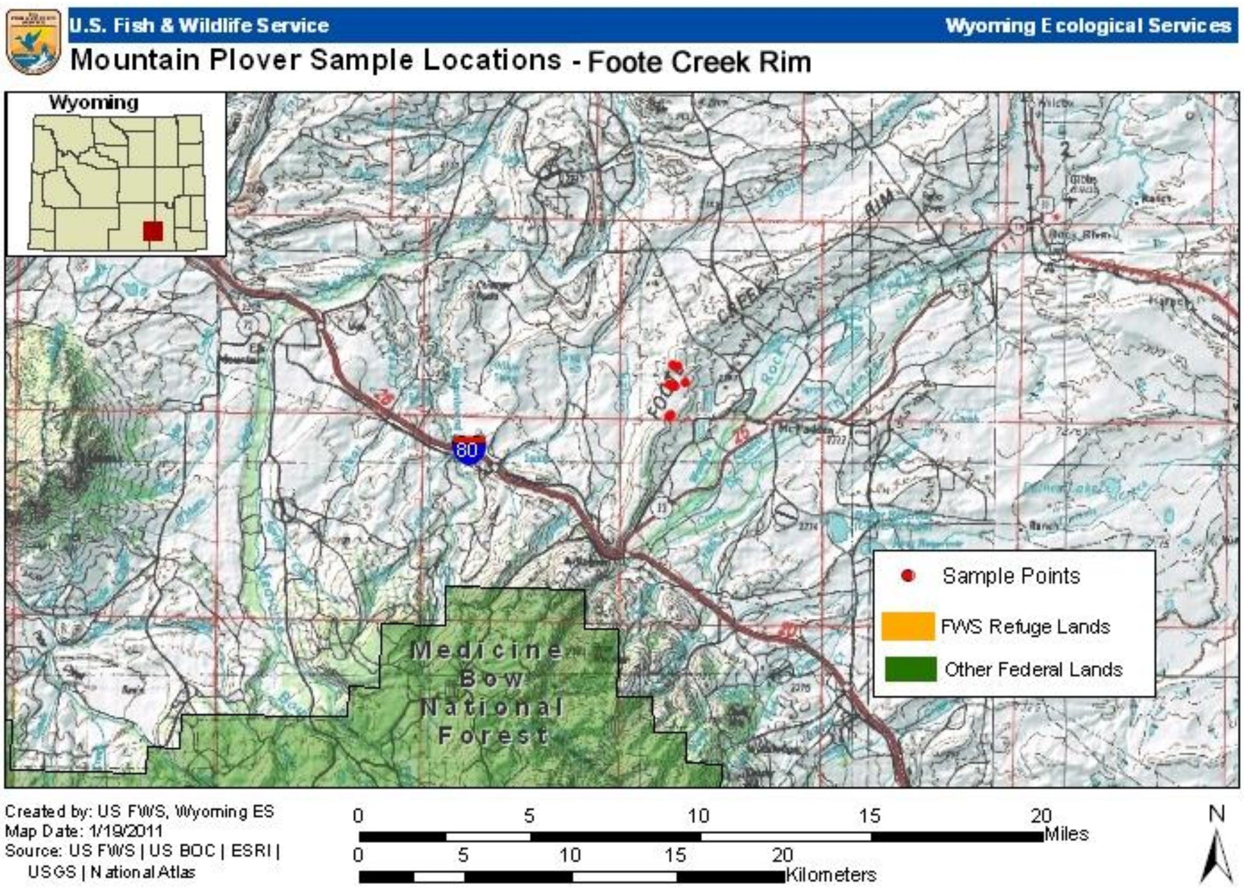

Figure 7. Foote Creek Rim sampling locations.

Archived Mountain Plover Egg Sampling Locations

Archived mountain plover eggs collected in 2003 were submitted for organic chemical analysis using funds from this investigation. This information was used to demonstrate the ongoing exposure of mountain plover to organic compounds. Sites sampled in 2003 included a site in Albany County and another in the Shirley Basin located in Carbon County in southern Wyoming (Figure 8). These high elevation grasslands consist primarily of mixed-grass prairie and sagebrush, which supports pronghorn antelope, domestic cattle, and black-tailed prairie dogs (Plumb 2004). A third site, located in Park County in the northwestern Wyoming, was also sampled (Figure 8). This area is a desert-shrub dominated by greasewood (*Sarcobatus vermiculatus*) with some sagebrush and mixed grass prairie interspersed. Pronghorn antelope, domestic sheep and cattle, and white-tailed prairie dogs (*Cynomys leucurus*) are the primary inhabitants (Plumb 2004).

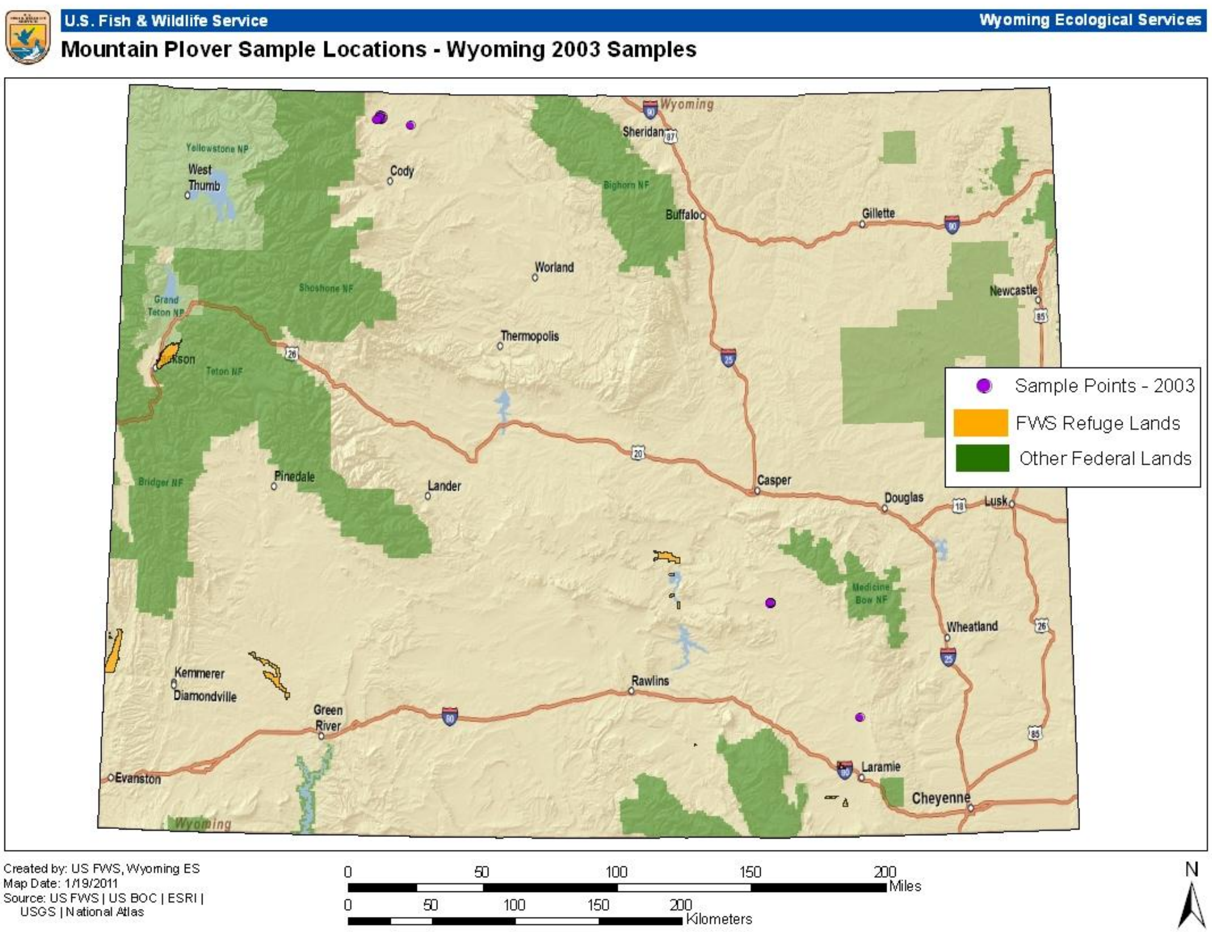

Figure 8. Archived mountain plover egg sampling locations.

Colorado

Mountain plovers nest across the eastern plateau region of Colorado, including a breeding stronghold in Weld County (Knopf and Rupert 1996). Samples collected for this investigation were primarily collected in Weld County on the Pawnee National Grassland (PNG). PNG is a shortgrass prairie managed by the USFS and is known internationally for the birding opportunities. Additionally, pronghorn antelope, mule deer, and many other small mammal species inhabit this grassland.

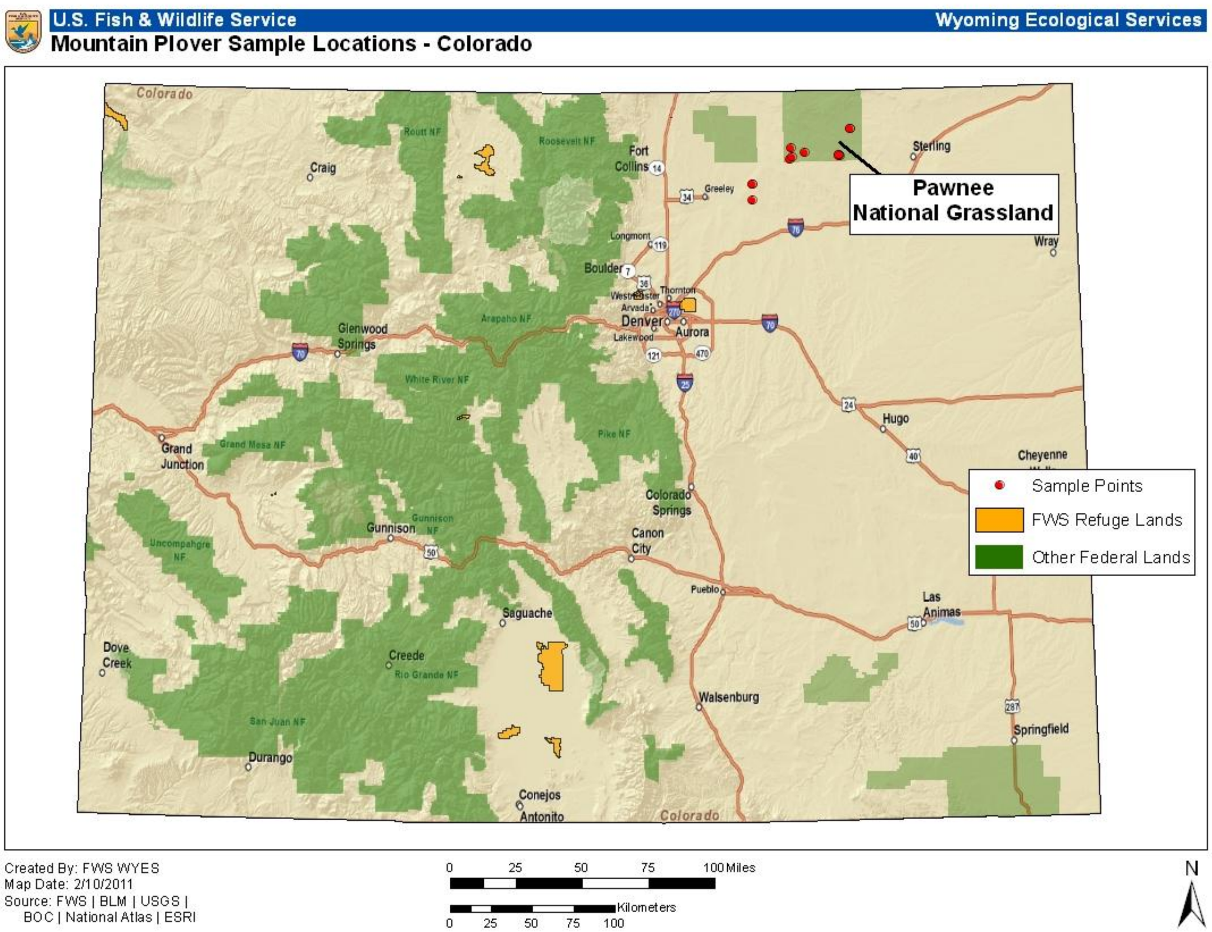

Figure 9. Sampling locations in Colorado.

Montana

Several known breeding grounds in Montana were selected as study sites. These included public lands administered by the BLM and Charles M. Russell, Lake Mason, and Hailstone NWRs in north-central and central Montana (Figure 10).

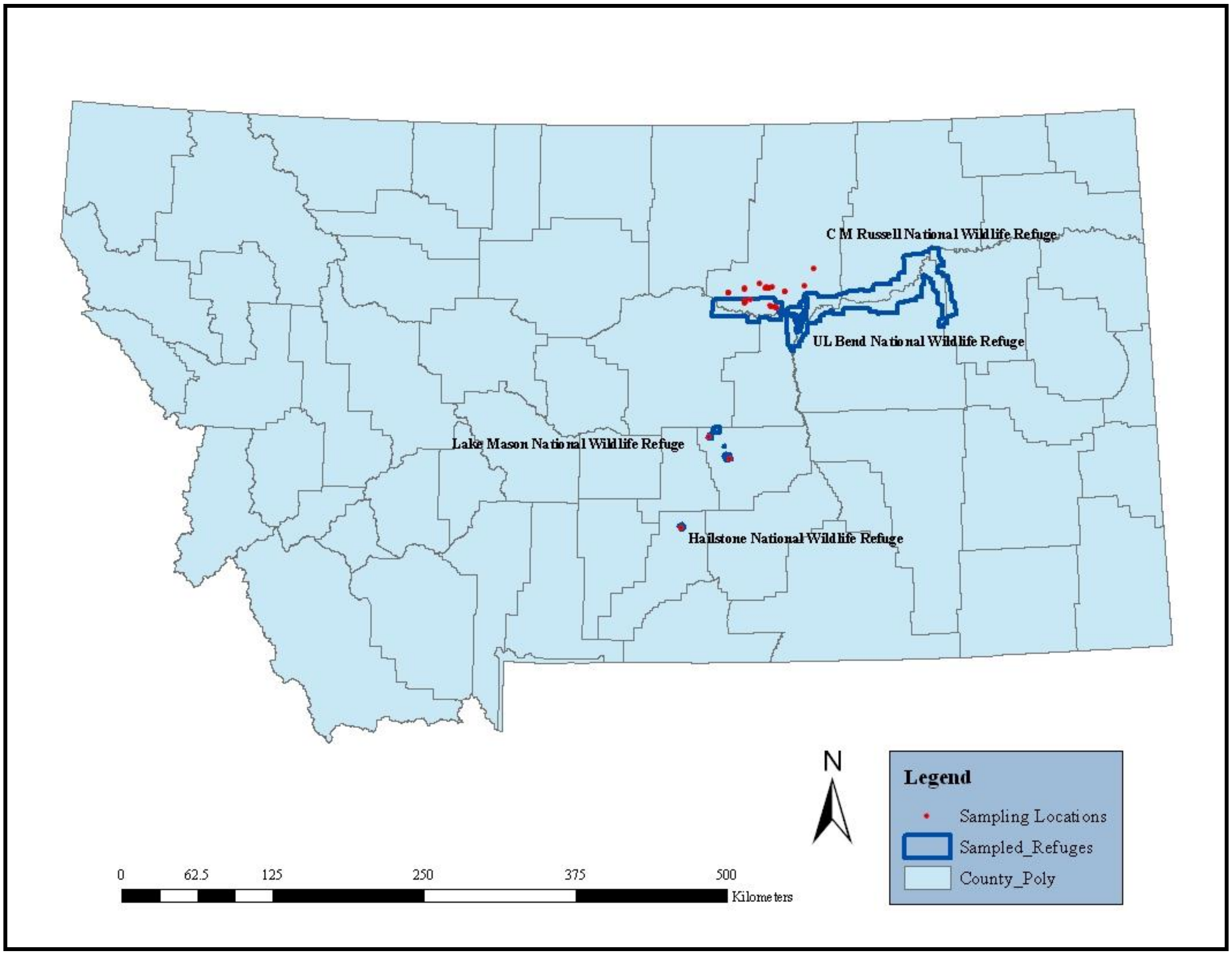

Figure 10. Sampling locations in Montana.

Southern Phillips County (CMR NWR, BLM, State and Private lands)

Southern Phillips County in Montana is thought to contain not only the largest mountain plover breeding populations in Montana but also one of the largest breeding populations in North America (Dinsmore 2001). Study sites located in southern Phillips County included Charles M. Russell (CMR) NWR and the adjacent BLM and Montana State School Trust properties. These areas consist of rolling uplands interspersed with steeply eroded ravines. Sagebrush and interspersed shortgrass prairie dominate the habitat (USFWS 2010). Mountain plovers nest almost exclusively on active black-tailed prairie dog towns in this part of Montana. Vegetation in these colonies is sparse, but includes such species as fringed sagewort (*Atemisia frigida*), plains prickly pear (*Opuntia polycantha*), blue grama (*Bouteloua gracilis*), needle-and-threat grass (*Stipa comata*), and Sandberg bluegrass (*Poa secunda*). Prairie dog towns were mapped entirely in 2003, which showed that the towns covered more than 2,954 ha (7,300 acres) at CMR NWR (Jo Ann L. D. Dullum, Wildlife Biologist, CMR NWR, Pers. Comm. 2010). In 2002, prairie dog towns mapped on BLM, State, and private lands north of the refuge totaled 9022 ha (22,292 acres; Figure 11).

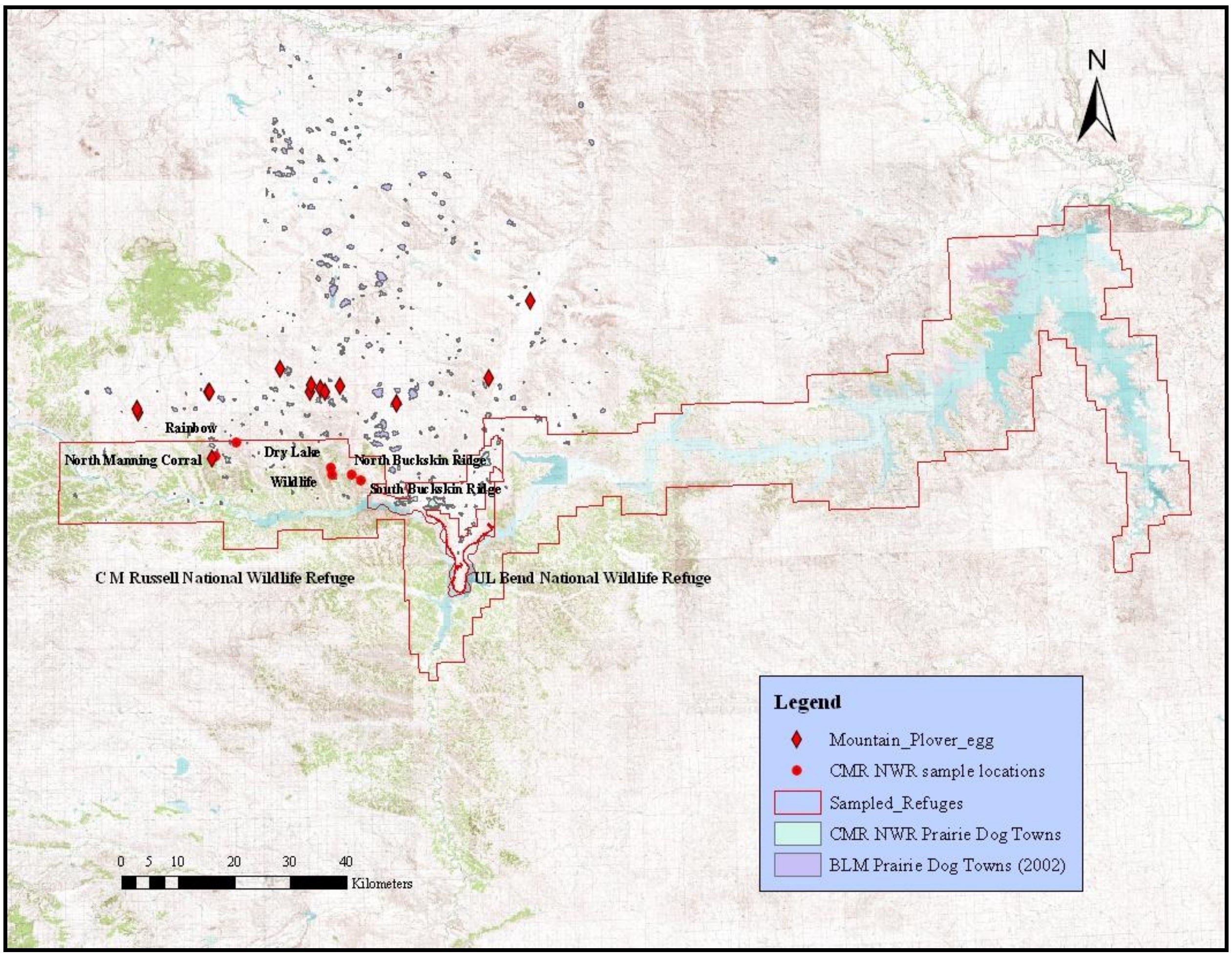

Figure 11. Charles M. Russell NWR, BLM, and State sampling locations.

Lake Mason NWR

Lake Mason NWR is located in central Montana approximately 12.9 km (8 miles) northwest of the town of Roundup (population 4,000) in Musselshell County. The refuge includes 6730 ha (16,630 acres) in fee title and 2227 ha (5,502 acres) in refuge easements. It is divided into three units: Lake Mason, Willow Creek Unit, and the North Unit. Lake Mason and the Willow Creek Units were the only units sampled during this investigation (Figure 12).

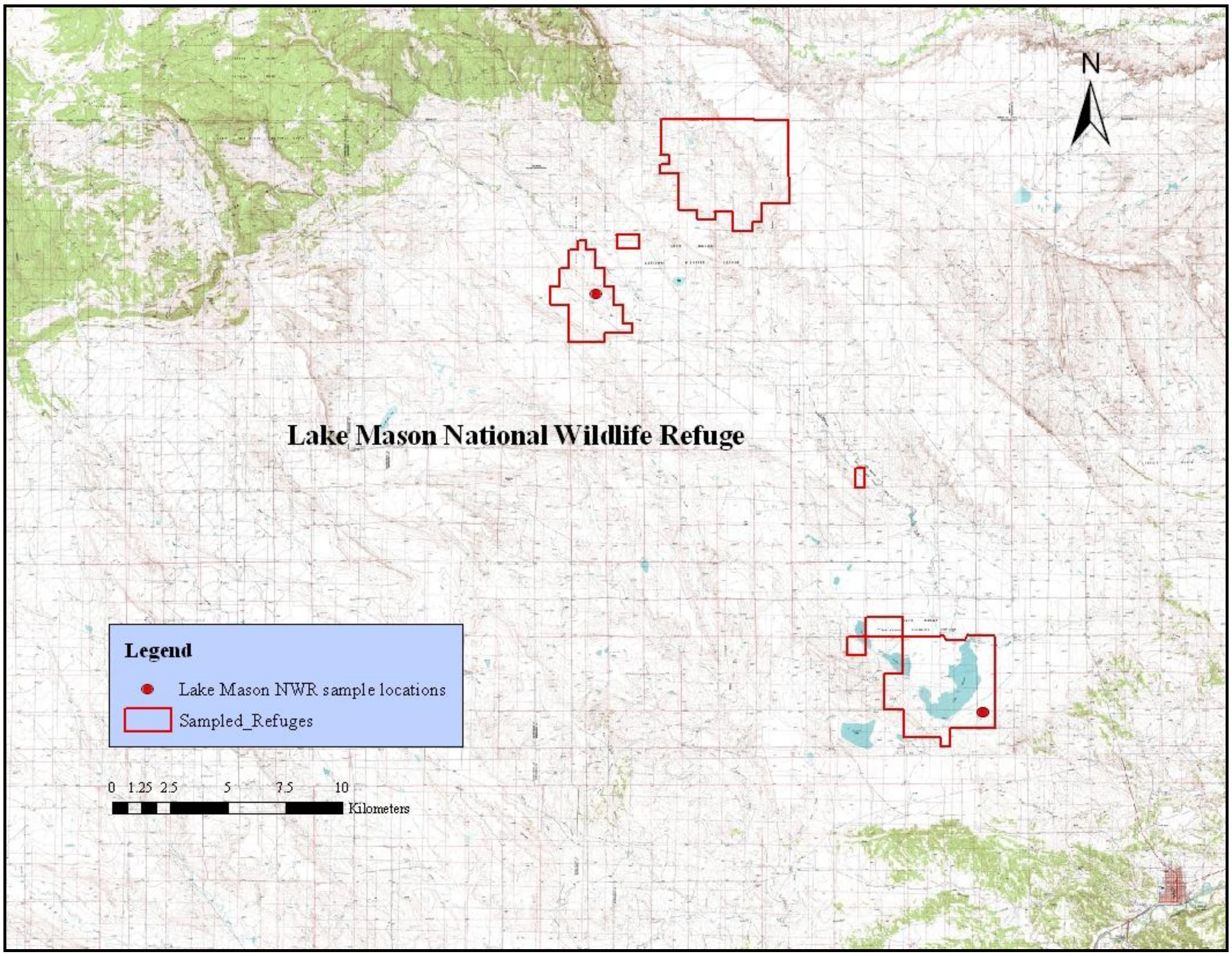

Figure 12. Lake Mason National Wildlife Refuge in Montana. Units from north to south are the North Unit, Willow Creek Unit, and Lake Mason.

Lake Mason Unit (LMU) is a 526 ha (1,300 acre) enhanced wetland surrounded by rolling shortgrass prairie hills. The lake is fed and drained by South Willow Creek. Water in the creek is mainly from runoff and agricultural return water is minimal. During this investigation, Lake Mason was dry and contained active prairie dog town located on the western portion of the lake. This colony was mapped in 2002 and at that time it covered 193 ha (478 acres; Jo Ann L. D. Dullum, Wildlife Biologist, CMR NWR, Pers. Comm. 2010).

The Willow Creek Unit of Lake Mason NWR is located approximately 19 km northwest of the LMU, is 874 ha (2,160 acres) in size and is managed to maintain a healthy shortgrass prairie community. Mountain plovers are attracted to this area as are many other migratory birds typical of shortgrass prairie ecosystems. The prairie dog town on this unit was mapped in 2002 and covered 190 ha (469 acres; Jo Ann L. D. Dullum, Wildlife Biologist, CMR NWR, Pers. Comm. 2010).

Hailstone NWR

Hailstone NWR, located in Stillwater County, approximately 5 km northeast of the town Rapelje and is part of a large closed basin located in south-central Montana. The refuge was created in 1942 by an Executive Order of President Franklin D. Roosevelt as an easement refuge of 1112 ha (2,748 acres). This contains approximately 51 ha (126 acres) of prairie dog towns based on mapping completed in 2002 (Jo Ann L. D. Dullum, Wildlife Biologist, CMR NWR, Pers. Comm. 2010) (Figure 13).

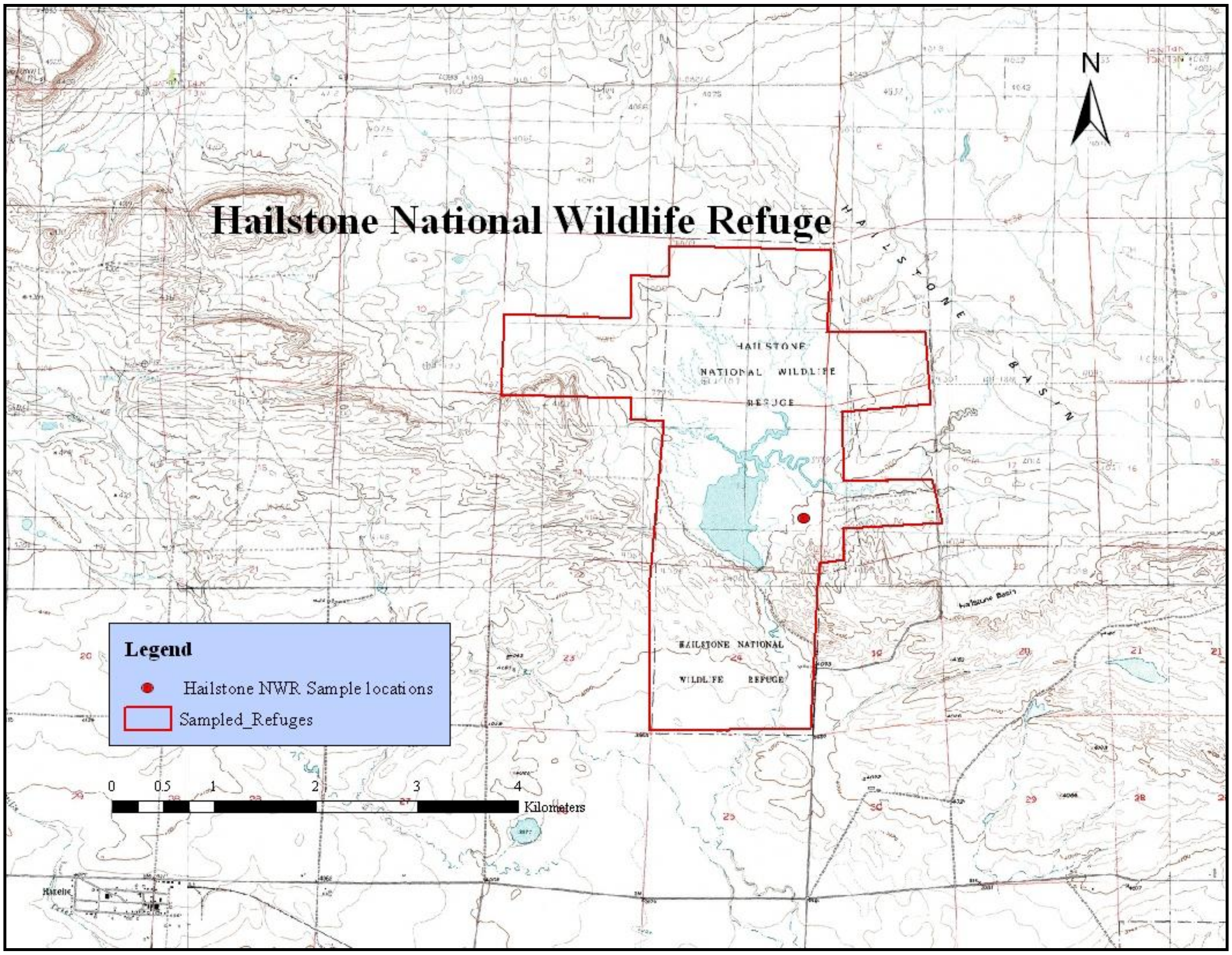

Figure 13. Hailstone NWR sampling locations

Sample Collection and Processing

Wintering Grounds

Samples of soil and soil invertebrates were collected in early May 2005, by environmental contaminant biologists from the Carlsbad Fish and Wildlife Office (CFWO) and by refuge biologists. As indicated previously, samples were collected from three off-refuge fields in Imperial Valley, one on-refuge field in Imperial Valley, and one on-refuge field in Central Valley (Kern NWR).

Composite surface soil and insect samples were collected from five stations in each field. Soil samples were collected using stainless steel equipment that was either pre-cleaned (dedicated) or cleaned between stations using standard protocols (USEPA/ERT 1994) requiring phosphate-free detergent, dilute nitric acid, acetone, and distilled water. Each station was defined by a circle with a radius of one meter and twelve pitfall traps were positioned in each circle using the layout in Figure 14. A labeled stake was placed in the center to help re-locate the station. Holes were dug using a bulb planter and trowels for pitfall trap placement.

Figure 14. Pitfall trap design (arrow depicts 1 m radius).

Soils removed for the pitfall traps were placed in pre-cleaned stainless steel bowls and homogenized using stainless steel spoons to produce one composite soil sample for each station. A portion of the composite soil sample was placed in a WhirlPak® bag for total organic carbon (TOC) and grain size. The remaining soil was placed in an I-Chem® jar for inorganic and organic chemical analysis.

Pitfall traps were 11.3 cm (4.5 inch) high 528 mL (16 fluid ounce) cups. These traps tended to be narrow, which made it difficult for large insects to escape once they fell into the cup. To avoid introduction of sampling artifacts, no water or solvent was added to the traps to immobilize insects once they had fallen in the trap.

Pitfall traps were left in place over night. The next day, all insects in each of the 12 cups at a station were composited into one sample and some sweep netting was performed to augment the sample. However, because the traps had soil in them, which made it almost impossible to separate insects from the soil in the field, the contents from pitfall traps and net sweeps were put into labeled sample bags and placed on ice for further processing at the lab at CFWO. Once at the lab, insects were separated from any clumps of soil that may have fallen into the traps, transferred to cleaned glass jars, and placed in the freezer. Samples consisted primarily of spiders and to lesser extent beetles. Sample weights averaged 1 gram, limiting the number of analyses (inorganic and organic) that could be performed. Once processed, all samples were stored frozen until they were shipped to laboratories designated by the Service's Analytical Control Facility (ACF) for chemical analyses.

Soil samples from Imperial and Kern were analyzed for metals, organochlorine compounds (OCs) including polychlorinated biphenyls (PCBs) and pesticides, organophosphates (OPs), triazine herbicides, sulfur, trifuluralin, and perchlorate. All insect samples were analyzed for metals and trifluralin. Because of the small sample sizes, only a subset of the insect samples was analyzed for OCs.

Breeding Grounds

Samples collected on the breeding grounds included soil, terrestrial insects, and mountain plover eggs. These matrices were collected from the study area locations in Montana, Wyoming, and Colorado (Figures 6, 7, 8, 9, 11, 12, and 13). The number of eggs collected from the different locations depended on egg availability. Eggs were collected by hand with no more than one egg collected from any nest. In Montana, eggs were collected in May and June of 2006 and 2008 from southern Phillips County by graduate students under the direction of mountain plover researcher Dr. Stephen Dinsmore. These eggs were collected from abandoned or failed nests, and all remaining eggs from these nests were collected. Many of the eggs collected from failed nests in Montana had cracked eggshells. These eggs were only dissected into jars to reduce handling. Wet weight concentrations of contaminants of these eggs are likely elevated from possible desiccation. Dry weight concentrations should be comparable to literature values. Mountain plover researcher, Dr. Fritz Knopf, collected mountain plover eggs from Wyoming and

Colorado sites in May and June 2006 and 2007.

Eggs collected by environment contaminant biologists were processed using standard protocols (Hudson River Natural Resource Trustees 2002). All eggs were placed in cartons and transported immediately to the lab for processing by biologists using standard protocols adopted for studies on the impacts of PCBs in the Hudson River (Hudson River Natural Resources Trustees 2002).

Intact eggs were gently cleaned with distilled water, weighed, and breadth and width were measured to the nearest 0.1 mm using a dial caliper. The volume was measured as the weight of water displaced by the egg. A scalpel or curved scissors was pre-rinsed with dilute nitric acid followed by distilled water and used to cut the shell around the equator. Contents were aged and examined for abnormalities and malpositioning. If an embryo was present, it was further evaluated for evidence of conspicuous malformations (e.g., missing limbs, malformed beaks). To minimize potential loss of the sample and prevent cross-contamination that could result from physical manipulation, embryos were not evaluated for subtle malformations that required measurements. Egg contents that were in various stages of decomposition made the assessment of some embryos difficult if not impossible. Once observations were recorded, contents were placed in certified cleaned amber glass jars and frozen until they could be submitted for chemical analyses by a laboratory under contract with ACF. Eggs were analyzed for metals, OCs, and total PCBs in 2006. In 2007 and 2008, eggs were analyzed for OCs and trifluralin.

Eggshells were placed in cartons to dry at room temperature for a minimum of 30 days. Once dry, the thickness of each eggshell (shell + shell membrane) was measured at four points around the girth with a Mitutoyo micrometer, which was fitted with ball attachments and accurate to 0.01 mm. Some eggshells had hardened yolk residue that could not be removed even at the time the contents were harvested. This was generally confined to one side of the shell and was avoided when taking measurements for shell thickness. Eggshell thickness was measured by methods described in Bunck et al. (1985) and Ratcliffe (1970).

Archived mountain plover eggs collected in 2003, that were not collected specifically as part of this investigation, were submitted for organic chemical analysis using funds from this investigation. These eggs were collected by University of Wyoming graduate student, R.E. Plumb. The number of eggs collected from the different locations depended on egg availability. Eggs were collected in June and July of 2003 and no more than one egg was collected from any nest (Plumb 2004). Service personnel dissected the eggs according to the methods previously described. Eggs were analyzed for OCs, PCBs, and trifluralin to demonstrate the presence of organic compounds and that exposure to mountain plover is ongoing.

Soil and terrestrial insect samples were collected in May and June of 2006. In Montana this was completed by the Service's Montana Field Office personnel and in Wyoming and Colorado by the Service's Wyoming Field Office personnel. Insect samples were collected using the same methods described in the wintering grounds sampling. Traps were left out overnight. In Montana, sweep netting was also used to augment the pitfall trap insects. All trap and net samples were composited into WhirlPak® bags and frozen until contents could be sorted with chemically-cleaned Teflon® tweezers. All insects were placed in chemically-cleaned amber glass jars and frozen.

Because foraging birds remain close to their nesting areas throughout the season (Knopf and Wunder 2006), sampling for insects was limited to one event and focused in areas where the birds were observed foraging. Samples of soil and insects were analyzed for metals, OPs, OCs, and total PCBs by the same laboratories listed above.

Chemical Analyses

Samples of soil and invertebrates from California sites, and soil, terrestrial insects, and mountain plover eggs samples collected on the breeding grounds were shipped to ACF designated laboratories for analyses, under catalog numbers 1040078 and 1040079, for California, 6070089 and 6070096 for Montana, and 6030187 and 6030192 for Wyoming and Colorado.

Samples were analyzed for organic contaminants, soil TOC and soil grain size by Geochemical and Environmental Research Group in College Station, Texas. Analyses for inorganic constituents were conducted by Trace Element Research Laboratory in College Station, Texas.

The percent TOC was determined by measuring carbon dioxide produced on ignition of acidified, freeze-dried sample, using an infrared detector. Grain size distribution was determined as percent sand (>0.0063 mm), silt (0.0039 mm to 0.063 mm) and clay (<0.0039 mm) using sieves and settling columns after sample had been treated with hydrogen peroxide and a dispersing agent. For metals, samples were acid extracted, then analyzed using hydride generation atomic absorption spectrometry (selenium and arsenic), cold vapor atomic absorption spectrometry (for mercury) or Inductively Coupled Plasma Emission (ICP) spectrometry (other metals).

To determine concentrations of the organic compounds (pesticides, total PCBs, and trifluralin), samples were first extracted with methylene chloride and cleaned using gel-permeation chromatography. Silica gel chromatography was used for additional cleaning and separation of PCBs. Samples were then analyzed by gas chromatography with an electron capture detector (pesticides and PCBs) or high resolution gas chromatography-mass spectrometry in Selective Ion Monitoring mode (for certain PCB congeners).

The target analytes and method detection limits reported by the contract labs follow. Target analytes for soil samples included the following parameters: % moisture, % TOC, and grain size distribution. Target analytes for soil, invertebrate, and egg samples for organic compounds included: PCB-total[1] (polychlorinated biphenyls as Aroclors), aldrin[2], alpha-, beta-, gamma, and delta-BHC[2] (s), alpha- and gamma-chlordanes[2], chlorpyrifos[2], dieldrin[2], endosulfan II[2], endrin[2], heptachlor[2], heptachlor epoxide[2], HCB[2] (hexachlorobenzene), HCH[2] (hexachlorocyclohexane), mirex[2], cis- and trans-nonachlor[2], oxychlordane[2], o,p'- and p,p'-DDD[2] (dichlorodiphenyldichloroethanes), o,p'- and p,p'-DDE[2] (dichlorodiphenyldichloroethylenes), o,p'- and p,p'-DDT[2] (dichlorodiphenyltrichloroethanes), pentachloro-anisole[2], 1,2,3,4- and 1,2,4,5-TeCB[2] (tetrachlorobenzenes), toxaphene[1], tetrachlorobenzenes[2] (1,2,3,4- and 1,2,4,5-), and trifluralin[2]. Results of analyses for organic contaminants are reported as ng/g or parts per billion (ppb). The dry weight detection limits are as follows: [1]1.43 as µg/kg or ppb; [2]0.143 as µg/kg or ppb.

The target analytes for soil, invertebrate, and egg samples for inorganics included: aluminum[1], arsenic[2], barium[2], beryllium[3], boron[1], cadmium[3], chromium-total[4], copper[4], iron[1], lead[5], magnesium[5], manganese[7], mercury[6], molybdenum[5], nickel[5], selenium[2], strontium[4], vanadium[4], and zinc[7]. Results of analyses for inorganic contaminants are reported as µg/g or parts per million (ppm). The dry weight detection limits are as follows: [1]10.2 as mg/kg or ppm; [2]0.5 as mg/kg or ppm; [3]0.2 mg/kg or ppm; [4]1.0 as mg/kg or ppm; [5]5.0 as mg/kg or ppm; [6]0.1 mg/kg or ppm; [7]0.5 mg/kg or ppm.

Data analysis

Analytical results were provided by contract labs as both wet weight (ww) and dry weight (dw) based concentrations. To be consistent with the various screening values, it was necessary to consider both ww-based and dw-based contaminant levels because dw-based concentrations are used to evaluate contaminant levels in soils, whereas either ww or dw-based concentrations may be used to evaluate contaminant levels in biota.

The percent moisture reported for each sample is provided to enable conversion between ww and dw concentrations as follows.

Wet weight concentration = dry weight concentration x (f_{solids}), or

Dry weight concentration = wet weight concentration / (f_{solids}), where

$f_{solids} = 1 - (\%moisture/100)$

Egg Data Analysis

Shell thickness for each egg was reported as the mean of four individual measurements. The mean, standard deviation, and 95% confidence interval was then computed for each species.

Contaminant levels in eggs were evaluated as ww concentrations. This was done to allow for adjustment for moisture loss that can occur due to the delay in time between when the egg was laid and when it was collected. Contaminant levels measured in bird eggs were adjusted accordingly using equations from the published literature (e.g. Stickel et al. 1983; Hoyt 1979) and from direct measurements with intact eggs.

Mixtures

DDT and its metabolites are a family of compounds (isomers) that occur as mixtures. Individual isomers (e.g. p,p'-DDE) can be evaluated individually but it is also desirable to evaluate the distribution and potential risks posed by concentrations of mixtures as a whole. In general, the total DDT concentration was computed as the sums of the six individual compounds (o,p and p,p'- DDD, DDE and DDT) with ½ the detection limit used as a surrogate for those that were below the limit of detection.

Screening for risk

To screen for ecological risks, dry weight concentrations of contaminants measured in soils were compared with U.S. Environmental Protection Agency (USEPA) ecological soil screening levels (Eco-SSLs; Table 1). The USEPA adopted a protocol for deriving Eco-SSLs in 2000 and has since developed Eco-SSLs for 15 of the target analytes in this study. The Eco-SSLs are ecological risk-based soil screening levels derived in a standardized manner and are based on contaminant risks to soil microorganisms, soil invertebrates, plants, birds and mammals. Separate values were derived for each of the receptors for which data of adequate quantity and quality were available. The Eco-SSLs for invertebrates and plants are the means of concentrations that affect 10% to 20% of exposed organisms (10-20% effect levels), or are maximum acceptable concentrations computed from No Observed Effect Concentrations

(NOECs) and Low Observed Effect Concentrations (LOECs). The Eco-SSLs for wildlife are calculated using literature-based toxicity reference values (TRVs), which are high end No Observed Adverse Effect Levels (NOAELs as daily dose rate), combined with bioaccumulation factors for highly exposed forage and prey species. The Eco-SSLs were used preferentially over other currently available ecological risk-based screening levels. Most Eco-SSLs were in draft form in 2006, and were finalized in subsequent years.

Table 1. Eco-SSLs[1] (ug/g dry weight in soil) showing show the concentrations of contaminants in soil that are protective of ecological receptors which commonly come into contact with and/or consume biota living in or on soil.

Trace Element	**Plants**	**Soil Invertebrates**	**Wildlife**	
			Avian	**Mammalian**
Arsenic	18	NA[2]	43	46
Barium	NA	330	NA	2,000
Beryllium	NA	40	NA	21
Cadmium	32	140	0.77	0.36
Chromium	NA	NA	Cr III - 26 Cr VI-NA	Cr III – 34 Cr VI - 130
Cobalt	13	NA	120	230
Copper	70	80	28	49
Lead	120	1,700	11	56
Manganese	220	450	4,300	4,000
Nickel	38	280	210	130
Selenium	0.52	4.1	1.2	0.63
Vanadium	NA	NA	7.8	280
Zinc	160	120	46	79
Organochlorines				
Dieldrin	NA	NA	0.022	0.0049
DDT & metabolites	NA	NA	0.093	0.021

[1]Eco-SSLs - USEPA 2000a and b; USEPA 2005a-f; USEPA 2007a-h; USEPA 2008
[2]NA = Not Available.

Concentrations of trace elements and two pesticides in soil samples collected from mountain plover wintering and breeding areas were compared to the Eco-SSL values to determine if concentrations detected could potentially adversely affect these birds directly by exposure through diet and incidental ingestion of soil or indirectly by impacting their food source (toxicity to soil invertebrates) or habitat (toxicity to plants).

Screening for Background

Because metals are naturally occurring constituents of soils, data on metals were also compared with background concentrations for surface soils to help managers with decisions regarding feasibility of actions to manage risk.

Data from large-scale studies and/or compilations for nation-wide application were used to identify ranges of concentrations that may be considered typical for undisturbed soils. The available data offer rough estimates at best of background concentrations because soil characteristics are highly variable from region to region, state to state, and even locale to locale. Data from Shacklette and Boerngen (1984) for surface soils from throughout the conterminous United States, specifically western states, and from Bradford et al. (1996) for soils from California were used to evaluate concentrations of naturally occurring inorganic analytes in soil samples from wintering grounds.

Soil samples from Imperial and Kern were analyzed for metals, organochlorine compounds (OCs) including polychlorinated biphenyls (PCBs) and pesticides, organophosphates (OPs), triazine herbicides, sulfur, trifuluralin, and perchlorate. All insect samples were analyzed for metals and trifluralin. Because of the small sample sizes, only a subset of the insect samples was analyzed for OCs.

In breeding areas, all soil and invertebrate samples were analyzed for metals and OCs (including PCBs and pesticides). In Wyoming and Colorado, these samples were also analyzed for OPs. Eggs collected in 2006 were analyzed for metals and OCs (including PCBs and pesticides). For 2003 archived eggs and eggs collected in 2008, analyses included OCs and trifluralin.

Quality Assurance

Laboratories used analytical methods and followed quality assurance (QA) and quality control (QC) protocols in accordance with requirements by ACF. A rigorous program of methods standardization and QA/QC assessment is maintained by ACF for all contract laboratories. Procedural blanks, duplicates, spiked samples, and analysis of standard reference materials were used routinely with each batch of samples to evaluate and maintain QA/QC. For digestion of all matrices for the ICP-MS semi-quantitative scan, quality control included digestion blanks, reference solutions and materials, samples replicate, and sample spikes. Quality control parameters for sample analysis by ICP-MS scan included running the single calibration standard as a sample, a measurement of precision by repeated runs of a reference solution, the analysis of independent-source laboratory control samples, and within-run monitoring of changes in the internal standards. For samples analyzed by flow injection atomic absorption (selenium), pre-digestion quality control included digestion blanks, replicates, spikes, and reference solutions/materials. Analytical quality control for selenium included calibration verification solutions and analysis spikes. For analysis of mercury in tissue by thermal combustion, amalgamation, and atomic absorption spectroscopy (DMA-80), quality control included calibration verification checks, reference tissues, replicates, method spikes, and blanks.

RESULTS AND DISCUSSION

Wintering Grounds

Soils-Inorganic Elements

Summary statistics for trace element concentrations in soil samples collected from two refuges in California and three sites in the Imperial Valley are contained in Table 2; full analytical results are listed in Appendix 1. The averages and ranges of inorganic constituents in soil samples from wintering areas in California were mostly within the western average and range of soil in the western U.S. (Shacklette and Boerngen 1984), but some constituents were above the Eco-SSLs that are protective of birds and/or soil invertebrates. Average concentrations of beryllium, cobalt, manganese, molybdenum, and nickel in soil samples were slightly higher than the average reported for western soils but fell at the lower range of concentrations reported for western U.S. soils and were at or below mean background concentrations in California soils (Bradford et al. 1996). Only manganese in soil samples exceeded the Eco-SSL for plants and invertebrates.

Average concentrations of arsenic, barium, mercury, lead, and vanadium in samples were below the geometric mean for background in western U.S. soils (Shacklette and Boerngen 1984). Average concentrations of arsenic, cobalt, manganese, nickel and selenium in soil were lower than Eco-SSLs for the protection of birds. There are no established Eco-SSLs for barium, beryllium, boron, and mercury for the protection of birds. Concentrations of barium and beryllium were below Eco-SSLs for protection of soil invertebrates.

Individual boron concentrations in soil samples taken from Kern NWR were higher (range = 34.3 – 72 ug/g dw) than the averages reported for western U.S. soils, but were still at the lower end of the overall range of <20 – 300 ug/g dw (Shacklette and Boerngen 1984). Boron concentrations in soils from Kern NWR were all >15 ug/g dw considered to be a threshold for observable impacts on growth of sensitive plant species (Miwa et al. 2007). However, the concentrations of boron observed in these samples were considered to be below levels of concern for mountain plovers because their direct exposure via incidental ingestion of soil is only fraction of their diet.

Average concentrations of selenium in soil samples were within the ranges reported by Shacklette and Boerngen (1984), but some were elevated relative to background concentrations for soils specific to California (Bradford et al. 1996). Selenium concentrations measured in soil samples from Imperial Valley were high (Table 2), particularly in the actively cultivated fields where even the minimum concentrations ($\geq$0.55 ug/g dw) were greater than the maximum reported by Bradford et al. (1996) for background soils in California. All of the off-refuge fields sampled exceeded the Eco-SSL for protection of plants, but invertebrates and avian ecological receptor levels were not exceeded. While the elevated selenium levels observed in the actively cultivated fields from Imperial Valley are not based on geology alone (USDOI 1998), conditions in the Imperial Valley favor the accumulation of selenium introduced by irrigation with water from the Colorado River, which has elevated levels of selenium (USDOI 1998). Selenium concentrations in soil from Kern NWR were consistent with background concentrations reported by Bradford et al. (1996) for California soils (mean = 0.058 ug/g dw; range = 0.015 – 0.430 ug/g dw).

Average strontium concentrations measured in fields from California ranged from 224 ug/g dw to 441 ug/g dw (range = 216 – 504 ug/g dw), all of which exceeded the average background concentration for California soils (128 ug/g dw) and some were above the range for background (20 – 271 ug/g dw). Strontium is ubiquitous in the environment and present in nearly all types of rocks and soils (ATSDR 2004). Elevated concentrations in soils may result from atmospheric deposition of particles from coal fired power plants, pyrotechnic devises, and dust from areas where phosphate fertilizers have been applied. Releases directly to soil are primarily from application of solid waste and the use of phosphate fertilizers (ATSDR 2004). The toxicological implications for mountain plovers of elevated strontium concentrations in Imperial Valley soils are not known.

Average lead concentrations (14.0 – 18.9 ug/g dw) in soil samples collected from Imperial Valley were slightly above the Eco–SSL for the protection of birds; but it is unlikely that the lead concentrations in the Imperial Valley soil samples pose a significant threat to mountain plover (Eisler 1988b). Average concentrations of vanadium in soils from all of the California (34.8 – 42.0 ug/g dw) were greatly above the Eco-SSL of 7.8 ug/g dw for the protection of birds, but interpreting the risk posed by vanadium at measured concentrations in soil samples is difficult because information on vanadium's toxicity to wild terrestrial birds is scarce. In studies with domestic chickens (*Gallus domesticus*), adverse effects depended on the chemical form of vanadium and ranged from impaired growth in newly hatched to reduced egg production to mortality (Rattner et al. 2006).

No background cadmium values were reported by Shacklette and Boerngen (1984). However, concentrations measured in soils from actively cultivated fields in Imperial Valley exceeded both the geometric mean and the maximum reported for background in soils from California (Bradford et al. 1996). In addition, all of the samples collected from agricultural fields in Imperial Valley had cadmium concentrations exceeding the Eco-SSL for birds (0.77 ug/g dw) with averages ranging from 1.93 ug/g dw to 3.30 ug/g dw. In comparison, cadmium concentrations in soils from more passively cultivated fields in Imperial Valley (SBSS NWR) and the Central Valley (Kern NWR) were below 0.55 ug/g dw (Table 2) and were below levels of concern (the Eco-SSL) for avian wildlife (USEPA 2005d).

Average copper concentrations in soils from fields were between 17.5 ug/g dw and 33.7 ug/g dw, which are higher than the geometric mean, but well within the range of copper concentration reported for western U.S. soils (mean = 2.07 ug/g dw; range = 2 – 300 ug/g dw). These concentrations were only slightly higher than the range of copper concentrations reported for non-contaminated sites (Kabata-Pendias and Pendias 1992), and either did not or only slightly exceeded the Eco-SSL for avian wildlife (28 ug/kg dw). Copper deficiency or excess can be harmful to organisms, although reported toxic effects from excess dietary exposure in birds in field conditions are rare (Eisler 1997; USDOI 1998).

Average phosphorus concentrations measured in soil samples (803 – 3,316 ug/g dw) were elevated compared to the geometric mean concentration of 320 ug/g but were within the range of 40 ug/g dw to 4,500 ug/g dw for background soils in the western U.S. (Shacklette and Boerngen 1984). Phosphorus occurs naturally and is a primary ingredient in fertilizers (UNEP 2001). Birds require a specific level of phosphorus and the availability of phosphorus depends on the soil's pH. Lower pH conditions allow aluminum to become soluble, which if taken up by birds, competes with phosphorus and calcium needed for eggshell structure and proper growth during embryo development (Schwarzbach et al. 2006). Soils in the western U.S. are typically alkaline that readily alleviates this concern.

Zinc concentrations in soil samples from actively cultivated fields in Imperial Valley (range = 392 – 9,310 ug/g dw) were much higher than the geometric mean background concentration of 55 ug/g reported for the western U.S. (Shacklette and Boerngen 1984) and all samples greatly exceeded the respective Eco-SSLs for protection of birds (46 ug/kg dw) and soil invertebrates (120 ug/g dw). Zinc concentrations in soil samples from refuges were much lower, although several samples exceeded the Eco-SSL for protection of birds. Zinc occurs naturally but elevated concentrations in soil may be the result of application of certain fertilizers, atmospheric deposition from smelting operations of galvanized metal, or application of domestic and industrial biosolids (Eisler 1993).

Although not tested for statistical significance, it appears that concentrations of arsenic, barium, beryllium, cobalt, copper, lead, magnesium, manganese and selenium were higher in soils from Imperial Valley fields than in the field from the Kern NWR. Conversely, concentrations of sodium, boron, and potassium were higher in soil from the field at Kern NWR. These differences may reflect regional variation in conditions and influences. For example, soils at Kern NWR were generally saltier than those in Imperial Valley, while soils in the Imperial Valley had somewhat higher concentrations of selenium, possibly the result of irrigation with Colorado River water (USDOI 1998). Within Imperial Valley, soils from actively cultivated fields had higher concentrations of calcium, cadmium, phosphorus, sulfur, and zinc than soils from the more passively managed field on SBSS NWR. These differences appear to reflect the influence of land management practices. For example, calcium, phosphorus, sulfur, and zinc are among the nutrients added as fertilizers to support the growth of Bermuda grass crops. Sulfur is also the most commonly used fumigant on Bermuda grass crops, and cadmium may be present at elevated levels if biosolids are used on the fields.

Soils-Organic Compounds

Most organic pesticides were either not detected or were at very low concentrations in soil samples (Appendix 2; Table 3). The herbicide trifluralin is the third most heavily used pesticide in Imperial Valley for alfalfa and Bermuda grass crops (PAN 2010). Trifluralin was detected in all soil samples collected from Imperial Valley fields, including at SBSS NWR (Table 3). However, concentrations (range = 0.514 – 1.3 ng/g dw) were below mean concentrations detected in soils collected in 1972 for the National Soils Monitoring Program (<10 ng/g; Carey et al. 1979) and well below concentrations reported for soils the same year from fields in California (650 – 6,450 ng/g dw; Carey et al. 1979). Concentrations measured in soils from SBSS NWR were the same as concentrations measured in actively farmed fields nearby. This suggests that concentrations measured in the actively cultivated fields were not from recent applications. Instead, trifluralin concentrations measured on those fields and on SBSS NWR appear to reflect residual trifluralin transported by from area-wide non-point sources such as drift, and/or irrigation water.

Residues of DDT (o,p' and p,p') and its metabolites DDD (o,p' and p,p') and DDE (o,p' and p,p') were detected in virtually all soil samples, with higher concentrations occurring in soil samples from the Imperial Valley, including SBSS NWR (Table 3, Figure 15) than from the Central Valley. DDT was banned for use in the U.S. in 1972 but it is still transported via air, water, and animal movements from countries that continue to use the insecticide. DDE is a breakdown product of DDT and residues in soil may also be the result of historical agricultural use because DDE is extremely persistent (USDOI 1998). Twelve years after DDT was banned, total DDT concentrations in soils from agricultural fields in California were between 1.0 ng/g dw and 31,273 ng/g dw, which are orders of magnitude higher than concentrations measured in this study. However, total DDT concentrations in samples collected in 1984 from Imperial Valley were between 37 ng/g dw and 495 ng/g dw (average = 228 ng/g dw; Mischke et al. 1985), which is not greatly different from concentrations measured in Imperial Valley soils collected for this study in 2006 (average = 140 ng/g dw). The fraction of total DDT that is the parent compound (p,p'-DDT) has declined from approximately 20% in samples collected in 1984 (Mischke et al. 1985) to approximately 7% in samples collected from Imperial Valley in 2006 (Figure 16 and Table 3). While there was an approximately 2-fold decline in total DDT concentrations between 1984 and 2006, there was an approximately 3-fold decline in concentrations of parent compound

(DDT), which is consistent with an approximately 15 year half-life for DDT in soil. Although concentrations of total DDT in Imperial Valley soils have declined over time, they still ranged from slightly below to more than ten-times the Eco-SSL of 22 ng/g dw for protection of avian species.

Dieldrin was detected in all soil samples from fields. Aldrin, which is readily converted to dieldrin in the environment, was detected in approximately half of the samples. Although frequently detected, concentrations of dieldrin and aldrin were less than the Eco-SSL of 22 ng/g (0.022 ug/g dw) for avian species. The Eco-SSLs for DDT and dieldrin are designed to address risk posed by exposure to these contaminants, which is primarily through bioaccumulation in

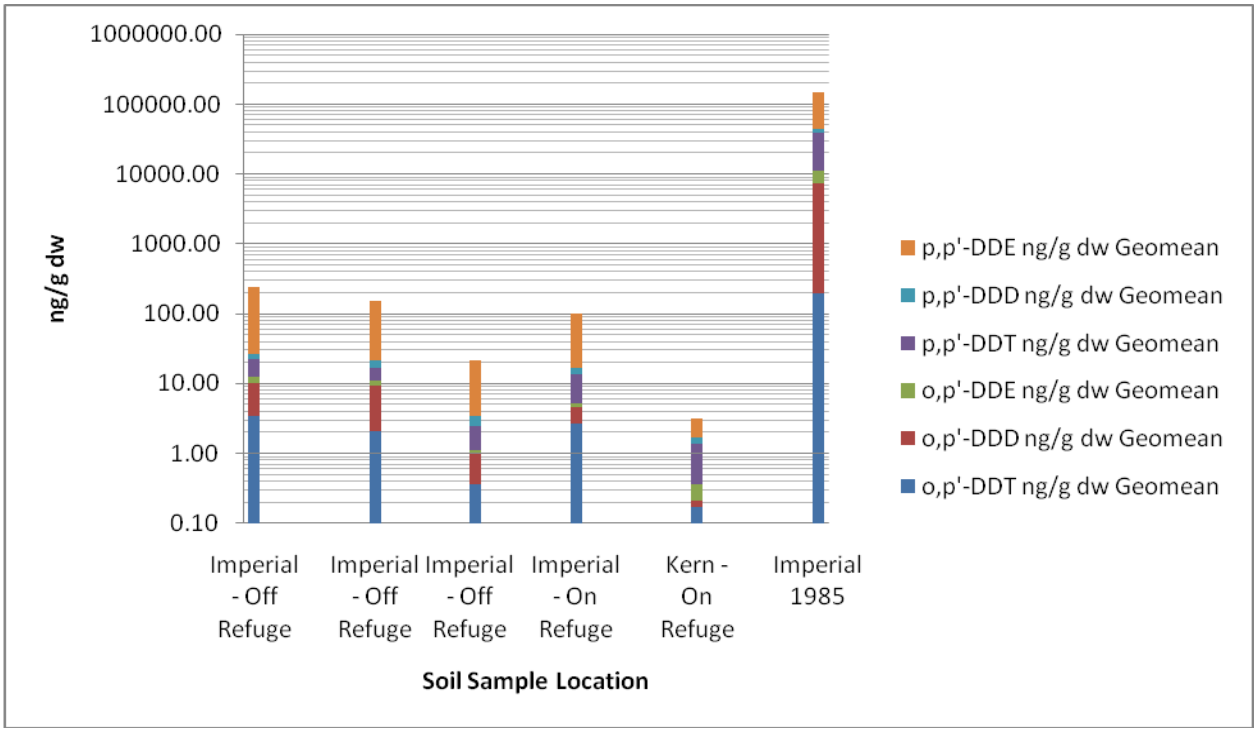

Figure 15. DDT isomer concentrations in soils from California (1985 and 2006)

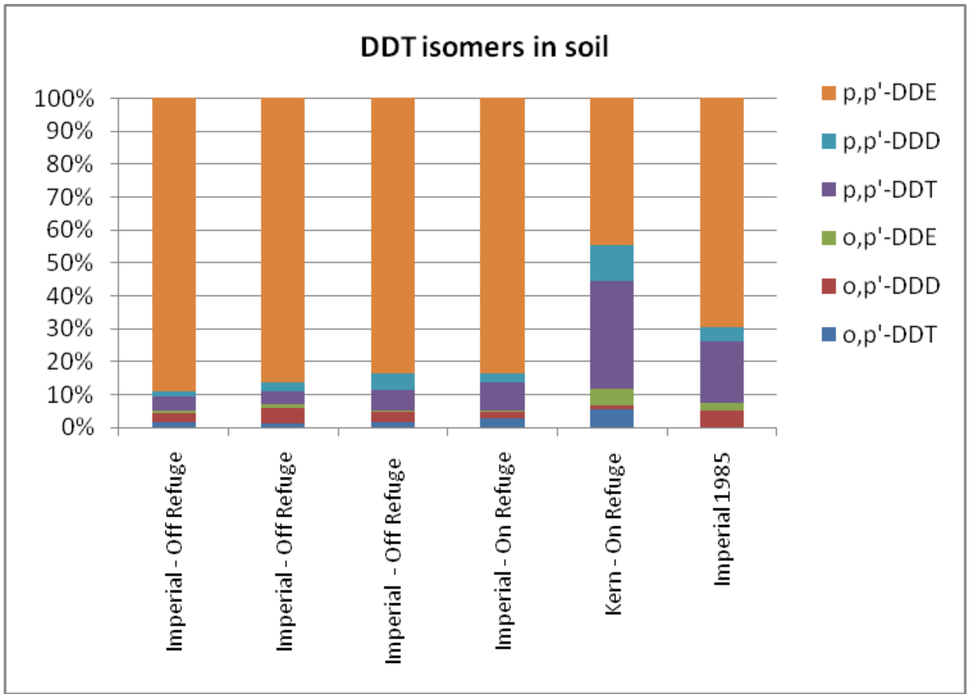

Figure 16. Percentage of DDT isomers comprising total DDT in California

food web organisms and incidental ingestion of soil. There are no Eco-SSLs for other potentially bioaccumulative contaminants detected in soil samples. These include substances such as chlordanes and HCHs that were detected at low levels. While concentrations of OC pesticides other than dieldrin and DDT may appear low in the soils, they may still pose a risk to plovers by bioaccumulating in the tissues of the soil invertebrates that plovers consume.

PCB concentrations in soils were low (arithmetic mean concentrations <110 ng/g dw; Table 3 and Appendix 3) and below levels associated with soils at contaminated sites (ATSDR 2000). Concentrations, as the sum of the congeners, in the most actively worked fields (Imperial Valley off-refuge) were between 36 ng/g dw and 175 ng/g dw and appeared to be significantly higher than concentrations measured in less intensively worked fields on refuge lands nearby (range = 15.3 – 20.3 ng/g dw). The field on Kern NWR, which has not been active for decades, had the lowest concentration (range = 4.75 – 8.84 ng/g dw). Atmospheric deposition contributes to PCB concentrations observed in environmental media. However, there may be additional sources for actively cultivated fields in Imperial Valley such as routine use of heavy farm equipment.

Table 2. Arithmetic mean and range of concentrations of select inorganics[1] (ug/g dry weight) in soil samples collected from mountain plover wintering sites in California, 2006, for comparison with geometric mean and range of inorganics in soils from the western United States as reported by Shacklett and Boerngen (1984).

Location and Samples		Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K
Imperial Valley	ave	19,900	6.56	7.42	313	1.11	81,400	1.93	7.82	30.9	31.2	17,520	0.016	4,424
Off-refuge	min	17,100	6.07	4.71	307	1.06	78,600	1.48	7.30	27.7	29.5	16,300	0.015	3,880
J20A - E (N=5)	max	23,500	7.05	10.4	324	1.20	84,800	2.54	8.41	33.4	32.8	18,900	0.016	5,050
Imperial Valley	ave	19,280	5.90	9.49	317	1.142	83,480	3.30	7.54	41.3	33.7	17,280	0.018	4,812
Off-refuge	min	17,900	5.74	7.73	309	1.050	77,000	1.87	7.17	27.5	28.5	16,900	0.017	4,100
J22A - E (N=5)	max	20,000	6.05	11.2	326	1.240	92,800	4.66	8.04	53.0	38.7	17,700	0.019	5,250
Imperial Valley	ave	23,180	5.72	6.82	292	1.25	77,540	2.65	8.24	35.9	29.2	19,220	0.016	4,812
Off-refuge	min	19,700	5.00	5.81	266	1.19	69,000	1.91	7.61	30.9	24.6	17,800	0.015	4,050
K18A-E (N=5)	max	24,900	6.25	8.92	313	1.30	91,600	3.78	8.50	42.0	34.3	19,800	0.017	5,170
Imperial Valley	ave	24,420	7.33	6.94	241	1.24	50,560	0.389	9.7	22.8	27.2	20,980	0.018	5,202
On-refuge; SBSS NWR	min	22,500	6.57	5.21	234	1.17	50,000	0.370	9.27	21.5	25.3	20,000	0.018	4,690
SB420A - E (N=5)	max	29,000	8.25	10.0	249	1.41	51,000	0.435	10.5	25.6	29.6	22,900	0.019	5,960
Central Valley	ave	17,180	2.92	48.1	126	0.486	36,460	0.404	5.64	26.1	17.5	15,880	0.014	5,766
On-refuge; Kern NWR	min	12,800	2.03	34.3	110	0.363	29,600	0.349	3.85	22.0	10.6	12,100	0.009	4,580
K15A - E (N=5)	max	23,600	4.23	72.0	152	0.684	45,300	0.543	8.61	31.8	28.4	21,800	0.027	7,620
western U.S.	geomean	58,000	5.5	23	580	0.68	18,000	0.26*	7.1	41	2.07	21,000	0.46	18,000
background soils	min	5,000	<0.10	<20	70	<1	600	0.05*	<3	3	2	1,000	<0.01	1,900
	max	>100,000	97	300	5000	15	320,000	1.7*	50	2000	300	>100,000	4.6	63,000

[1] See Appendix 1 for complete list of inorganic constituent concentrations by sample

* California background (Bradford et al. 1996)

Table 2. cont.

Location and Samples		Mg	Mn	Mo	Na	Ni	P	Pb	S	Se	Sr	Zn
Imperial Valley	ave	14,240	485	0.91	1,222	18.5	1,872	14.0	1,420	0.68	407	2,564
Off-refuge	min	13,200	461	0.51	804	17.7	1,370	13.4	1,190	0.56	392	1,130
J20A - E (N=5)	max	14,900	506	1.22	2,640	19.8	2,260	14.9	1,610	0.76	418	3,900
Imperial Valley	ave	14,040	500	1.049	1,275	19.5	3,136	14.1	2,094	0.915	441	5,708
Off-refuge	min	12,900	482	0.505	995	18.5	2,740	13.4	1,920	0.717	399	1,170
J22A - E (N=5)	max	15,000	548	1.390	1,460	21.3	3,650	14.9	2,330	1.11	504	9,310
Imperial Valley	ave	14,100	460	0.507	958	19.8	2,488	16.2	1,184	0.605	391	1,432
Off-refuge	min	12,700	436	0.505	804	19.0	1,840	14.4	1,080	0.550	338	392
K18A-E (N=5)	max	14,700	478	0.510	1,140	20.1	3,060	17.6	1,300	0.716	482	2,700
Imperial Valley	ave	14,920	499	1.22	1,428	21.9	803	18.9	814	0.392	224	78.7
On-refuge; SBSS NWR	min	14,400	478	1.10	1,190	20.4	781	17.6	646	0.366	216	75.2
SB420A - E (N=5)	max	16,000	534	1.29	1,700	23.3	822	21.0	1,180	0.418	233	84.3
Central Valley	ave	12,980	398	1.24	5,484	21.8	1,848	6.52	754	0.087	314	56.7
On-refuge; Kern NWR	min	9,600	317	0.51	3,180	17.4	1,410	4.94	387	0.075	235	44.4
K15A - E (N=5)	max	18,600	531	3.08	8,950	28.7	2,120	8.27	1,340	0.114	394	79.4
western U.S.	geomean	7,400	380	0.85	9,700	15	320	17	1,300	0.23	200	55
background soils	min	300	30	<3	500	<5	40	<10	<800	<0.1	10	10
	max	>100,000	5,000	7	100,000	700	4,500	700	48,000	4.3	3000	2100

Table 3. Arithmetic mean and range of concentrations of selected organic analytes (ng/g dry weight) in soil samples collected from mountain plover wintering sites in California, 2006.

Location and samples		DDD (o,p' + p,p')	DDE (o,p' + p,p')	DDT (o,p' + p,p')	DDTs- total[2]	Chlordanes[3]	HCHs[4]	Dieldrin & Aldrin[5]	PCBs - Aroclors	PCBs congeners	Trifluralin	Chlorpyrifos
Imperial Valley	ave	11.1	232	14.2	258	5.56	0.112	1.94	42.2	50.0	0.97	0.798
Off-refuge	min	6.83	134	8.51	155	4.09	0.093	1.44	27.3	36.0	0.549	0.266
J20A - E (N=5)	max	14.7	348	23.7	376	7.60	0.132	2.81	55.8	66.4	1.30	1.07
Imperial Valley	ave	14.3	152	9.23	176	4.76	0.105	2.08	37.5	114	1.02	0.707
Off-refuge	min	4.40	63	3.01	70.0	1.43	0.077	0.64	14.5	74.2	0.850	0.464
J22A - E (N=5)	max	24.7	253	16.8	292	7.63	0.126	3.45	59.4	175	1.20	1.05
Imperial Valley	ave	1.72	18.6	1.81	22.1	0.360	0.086	0.175	12.0	64.3	0.737	0.264
Off-refuge	min	1.20	11.3	1.19	14.4	0.301	0.077	0.139	8.87	45.4	0.573	0.177
K18A-E (N=5)	max	2.76	22.3	2.43	26.3	0.400	0.093	0.231	15.3	85.1	1.12	0.325
Imperial Valley	ave	4.51	86.9	11	103	0.301	0.378	0.276	12.5	17.5	0.829	0.619
On-refuge; SBSS NWR	min	4.17	60.5	9.44	74.2	0.269	0.305	0.248	10.9	15.3	0.514	0.489
SB420A - E (N=5)	max	5.02	111	13	129	0.336	0.410	0.289	13.7	20.3	1.30	0.798
Central Valley	ave	0.488	1.95	1.93	4.37	0.483	0.076	0.127	6.67	6.61	<0.260	0.058
On-refuge; Kern NWR	min	0.077	0.55	0.151	0.78	0.333	0.065	0.079	4.76	4.75	<0.252	<0.026
K15A - E (N=5)	max	0.85	3.74	4.53	9.12	0.70	0.105	0.240	8.91	8.84	<0.266	0.110

[1] See Appendix 1 for complete list of organic constituent concentrations by sample

[2] DDTs - total = [o,p'-DDD] + [p,p'-DDD] + [o,p'-DDE] + [p,p'-DDE] + [o,p'-DDT] + [p,p'-DDT]

[3] Chlordanes = [cis-chlordane] + [trans chlordane] + [cis-nonachlor] + [trans-nonachlor]+ [oxychlordane]

[4] HCHs = [alpha HCH] + [beta HCH] + [delta HCH]

[5] Dieldrin & Aldrin combined because Arden is readily converted to Dieldrin in the environment.

Terrestrial Invertebrates-Inorganic Elements

All California sampling sites had at least one invertebrate sample exceeding 1,000 ug/g dw of aluminum (Table 4; Appendix 4) and concentrations in those from SBSS NWR averaged 7,150 ng/g dw (Table 4). A dietary concentration above 1,000 ug/g dw is considered toxic to birds (Sample et al. 1996; Sparling and Lowe 1996). High levels of aluminum in the diet can affect the metabolism of calcium and phosphorus, which results in loss of eggshell quality, reduced growth in chicks, and/or decreased egg-laying in female birds (Sparling and Lowe 1996). Even so, a debate still remains on the risk to birds associated with elevated aluminum concentrations in the diet because bioavailability is not well known.

Arsenic is a common ingredient in herbicides and insecticides, which represent the largest source in agricultural fields (Eisler 1988a); but average concentrations of arsenic in terrestrial invertebrate samples from all wintering areas were below levels of concern for avian species (Table 4). The dietary NOAEL for arsenic, as a daily dose, is estimated to be 2.46 ug/g/day as copper acetoarsenite for the brown-headed cowbird (*Molothrus ater*), which is considered a sensitive species to arsenic (Sample et al. 1996). Mallards (*Anas platyrhynchos*) had an estimated NOAEL as daily dose of 5.14 ug/g/d with sodium arsenite. One individual invertebrate sample from SBSS NWR had an arsenic concentration of 4.5 ug/g dw. Using a body weight and a daily food ingestion rate more specific to plovers (Dunning 1984, Nagy 2001), the NOAEL for cowbirds translates into a dietary concentration for mountain plovers of approximately 30 ug/g dw. The maximum concentration observed in samples from California wintering grounds was 4.5 ug/g dw.

Barium concentrations in three individual invertebrate samples (47.8 ug/g, 33.8 ug/g, and 137 ug/g dw) were higher than any of the remaining 21 samples (Appendix 4), but these concentrations were well below an estimated NOAEL of 2,000 ug/g (Sample et al. 1996). In addition, beryllium was very low or below the detection limit for invertebrate samples (Wiemeyer et al. 2004).

Most research on dietary ingestion of boron by birds has occurred in waterfowl as a result of agricultural irrigation drainwater concerns (USDOI 1998); but, in laboratory studies where adult domestic chickens consumed 875 ug/g of boron as boric acid for six days, the only ill effect was egg production cessation, which returned to normal 14 days after the boron diet was removed (Eisler 1990b). However, boron is teratogenic if injected into domestic chicken eggs (Eisler 1990b). Boron concentrations in all but one of the invertebrate samples collected at California wintering grounds were below 30 ug/g (Table 4; Appendix 4) shown to affect growth in mallard ducklings (Sample et al. 1996; USDOI 1998).

Cadmium concentrations measured in invertebrate samples were all <1.2 ug/g dw. Laboratory studies suggest that dietary intake of <1 ug/g should not lead to toxicological effects in birds (Furness 1996). Chromium concentrations in soil invertebrates were <3.5 ug/g in all samples but one (19 ug/g dw), but this concentration does not represent a risk to birds even if considered in its most toxic hexavalent form (Eisler 1986).

Average copper concentrations in terrestrial invertebrates varied from 41.2 ug/g dw to 89.1 ug/g dw (Table 4). Little information exists on the toxicity of excess dietary copper to wild birds, although information based on poultry studies indicate that a diet of 300 ug/g is the maximum tolerable limit, which is well below copper concentrations in collected invertebrate samples. Typically, copper deficiency is more of a concern in birds' diet because it is a necessary nutrient (Eisler 1997; USDOI 1998).

Lead was detected infrequently, and in all but two samples, concentrations ranged from not detected (mean detection limit = 1.8 ug/g dw) to 2.6 ug/g dw. Concentrations in two samples from Imperial Valley fields were noticeably higher, at 7.2 ug/g dw in one off-refuge field and 11 ug/g dw in the on-refuge field at SBSS NWR (Appendix 4). Toxicological benchmarks indicate that dietary concentration of 10 ug/g as lead acetate has no effect on egg hatching success in Japanese quail (*Coturnix japonica*), whereas a concentration of 100 ug/g of lead impaired reproduction. In other bird species such as domestic chickens and pheasants (*Phasianus colchicus*), the growth of precocial hatchlings exposed to dietary lead levels of 500 ug/g was not affected (Hoffman et al. 1985). Dietary ingestion from food containing biologically incorporated lead is unlikely to result in toxicity, particularly at the level measured in invertebrates from fields in Imperial Valley (Beyer et al. 1988; Eisler 1988b).

Terrestrial invertebrates from SBSS NWR were higher in iron and magnesium than at other wintering sites where invertebrates were collected. These elements are important nutrients and required by living organisms in large amounts (Hulse et al. 1980). Manganese is also an important nutrient but is required in much smaller amounts and can be toxic at high concentrations. Manganese was highest in terrestrial invertebrates (maximum concentration = 226 ug/g dw) from SBSS NWR (Table 4; Appendix 4). With an estimated dry weight-based food ingestion rate of 0.180 g/g_{BW}-d for mountain plovers, the maximum observed manganese concentration in invertebrate samples translates into a daily dose rate for mountain plovers of approximately 41 ug/g_{BW}-d, which is much less than the daily dose of 977 ug/g/day shown to be the NOAEL for Japanese quail (Sample et al. 1996).

Mercury concentrations in invertebrates were below the detection limit (0.12 ug/g dw), but this is approximately ten-times greater than concentrations measured in co-located soils. Additionally, the wet weight-based detection limit for mercury in invertebrate samples was 0.06 ug/g, which exceeds dietary screening levels considered by USFWS (2003b) for the protection of western snowy plover (*Charadrius alexandrinus nivosus*) in California (0.009 ug/g or 0.026 ug/g depending on the uncertainty factor). However, the dry weight-based detection limit for mercury in invertebrates (0.12 ug/g) translates into a potential ingestion rate of 0.022 ug/g/day for mountain plovers, which is below the lowest NOAEL (0.030 ug/g/day) identified by USEPA (1995) for chronic exposure by avian species.

Molybdenum concentrations were low (Eisler 1989; USDOI 1998) in terrestrial invertebrate samples. Information available on nickel indicates that concentrations measured in terrestrial invertebrates were low, but whether they were below levels of concern for wild birds is not known (Weber and Reid 1968; Cain and Pafford 1981).

Table 4. Arithmetic mean and range of concentrations of select inorganics[1] (ug/g dry weight) in invertebrate samples collected from mountain plover wintering sites in California, 2006.

Location and Samples	Statistical Function	Al ug/g dw	As ug/g dw	B ug/g dw	Ba ug/g dw	Be ug/g dw	Cd ug/g dw	Cr ug/g dw	Cu ug/g dw	Hg ug/g dw	Mn ug/g dw
Imperial Valley	average	990	0.54	11	13.5	<0.1	0.528	1.08	56.3	<0.12	33.4
Off-refuge	minimum	150	<0.3	<10	1.8	<0.1	0.2	<0.5	25	<0.12	13
J20A - E (N=5)	maximum	3120	1.4	20	47.8	<0.1	0.84	3.5	94.9	<0.12	68
Imperial Valley	average	925.4	1.02	12.1	11.2	<0.1	0.684	1.44	89.1	<0.12	36.6
Off-refuge	minimum	343	<0.6	<7	4.8	<0.1	0.45	0.6	32.9	<0.12	25
J22A - E (N=5)	maximum	1810	2.1	37	18	<0.1	0.9	2.2	208	<0.12	49
Imperial Valley	average	1344	0.42	4.3	12.8	<0.1	0.786	2.4	48.3	<0.12	43.8
Off-refuge	minimum	1190	<0.5	6	10	<0.1	0.5	1.5	26	<0.12	35
K18A-E (N=5)	maximum	1540	0.75	6	15	<0.1	1.1	2.8	78.8	<0.12	50
Imperial Valley	average	7150	1.59	7.5	43.8	0.152	0.582	5.42	41.2	<0.12	91.7
On-refuge; SBSS NWR	minimum	3620	0.6	<4	13	<0.1	<0.1	1	24	<0.12	46
SB420A - E (N=5)	maximum	24500	4.5	18	137	0.56	1.2	19	63.7	<0.12	226
Central Valley	average	1585	0.896	8.2	39.9	<0.1	0.916	1.96	59.9	<0.12	49.9
On-refuge; Kern NWR	minimum	855	<0.6	<6	16	<0.1	0.6	1	31	<0.12	34
K15A - E (N=5)	maximum	2010	2.3	10	68.7	<0.1	1.2	2.7	102	<0.12	64.2

Table 4, cont.

Location and Samples	Statistical Function	Mo ug/g dw	Ni ug/g dw	Pb ug/g dw	Se ug/g dw	Sr ug/g dw	V ug/g dw	Zn ug/g dw
Imperial Valley	average	1.4	1.18	2.02	2.38	71.1	1.99	413
Off-refuge	minimum	<2	0.6	<0.8	1.4	9	<0.5	194
J20A - E (N=5)	maximum	3	2.4	7.2	3	301	6.1	592
Imperial Valley	average	2	1.19	0.42	2.92	25.6	2.08	550
Off-refuge	minimum	<2	<0.5	<0.5	1.6	20	0.7	427
J22A - E (N=5)	maximum	6	1.8	0.5	4.4	32.7	3.3	747
Imperial Valley	average	1	0.6	0.763	1.29	27.4	2.68	405
Off-refuge	minimum	<0.5	<0.5	<0.7	0.93	22.3	2.2	273
K18A-E (N=5)	maximum	1	1	2	1.6	38.8	3.2	606
Imperial Valley	average	1.4	3.88	3.32	1.40	85.8	11.5	181
On-refuge; SBSS NWR	minimum	1	1.5	1	0.78	27	3.4	138
SB420A - E (N=5)	maximum	2	11	11	2.8	298	36	215
Central Valley	average	1.2	2.5	0.62	0.608	212	4.2	159
On-refuge; Kern NWR	minimum	1	2.2	<0.6	0.5	43.4	2.7	118
K15A - E (N=5)	maximum	2	2.7	1	0.91	413	5.4	213

[1]See Appendix 4 for complete list of inorganic constituent concentrations by sample.

Average concentrations of selenium in invertebrate samples (0.608 – 2.92 ug/g dw) were consistently higher than average concentrations of selenium in co-located soil samples (0.087 – 0.915 ug/g dw). Birds may suffer reproductive impairment at a dietary range of 3-8 ug/g (USDOI 1998); and a range of 10 –15 ug/g dietary selenium exposure is the toxicity threshold for non-breeding birds exposed to winter stress (USDOI 1998). However, the selenium in invertebrate samples indicate that it is likely available for uptake and accumulation by organisms that constitute the mountain plover food web but overall does not present a risk to the birds.

Strontium concentrations were below 50 ug/g dw in most of the invertebrate samples collected. However, noticeably higher concentrations were observed with invertebrates from Kern NWR (four out of five samples = 127 – 413 ug/g dw), and in two samples from Imperial Valley (301 ug/g dw from an off-refuge field and 298 ug/g dw from SBSS NWR). Strontium is associated with calcium or potassium rich rock with weathering and atmospheric deposition being the primary input (Mora 2003). It is considered to have low toxicity (Wennig and Kirsch 1950), but it is unknown if the strontium levels measured in invertebrates pose a threat to mountain plover.

Little information exists on the toxicity of vanadium to wild birds, particularly terrestrial species. Research on acute toxicity and chronic toxicity of vanadium compounds to mallards and Canada geese *(Branta canadensis*) indicate that dietary effect levels may be greater than 250 ug/g, which is much higher than concentrations measured in invertebrates samples collected at the wintering grounds (Rattner et al. 2006).

Because zinc concentrations in soil samples from the Imperial Valley were higher than those from other wintering sites, it is not unexpected that terrestrial invertebrate samples from this area also had higher zinc concentrations. Zinc is an essential element but it can bioaccumulate in organisms and cause adverse effects at both high and low concentrations (USDOI 1998). Concentrations of zinc in invertebrates from the Imperial Valley sites were above levels shown to cause immunosuppression in young domestic chicks that were fed zinc at 178 ug/g for three weeks, although growth was not affected (Eisler 1993). Dietary concentrations of zinc that may affect the mountain plover are unknown.

Terrestrial Invertebrates-Organic Compounds

A few OCs were detected in terrestrial invertebrate samples (Table 5; Appendix 5). As with the soil samples, higher OC concentrations occurred samples from Imperial Valley, including SBSSNWR. DDE and two PCB congeners (#28 and #175) were detected in all of the invertebrate samples, reflecting the wide-spread occurrence of DDT and PCBs in general. PCB congeners #28 and #175 are not one of the more toxic co-planer PCB congeners. DDE concentrations in individual invertebrate samples from Imperial Valley ranged from approximately 48 ng/g dw to 1,310 ng/g dw, and averages ranged from 120 ng/g dw to 732 ng/g dw. The DDE concentration in invertebrates tended to be between 0.5 to 5.0 times the concentrations in corresponding soil samples (Figure 17). Total DDT concentrations were also higher in invertebrates than the soil collected from the same location (Figure 18).

Trifluralin, a dinitroaniline herbicide used to control annual grasses and broadleaf weeds, is widely used in the Imperial Valley. This herbicide is known to be persistent in soil, and current product labeling allows several applications during the growing season (USEPA 1996). Trifluralin was detected in most of the insect samples (13 out of 15) from actively cultivated fields in Imperial Valley, less frequently (1 out of 5) in the Imperial Valley field on SBSS NW, and not at all in the field at Kern NWR. Concentrations of trifluralin in invertebrates were 10 to 100 times the concentrations in corresponding soil samples (Figure 19).

According to the reregistration eligibility decision (RED) for trifluralin, the chronic level of concern was exceeded for birds. Additionally, trifluralin application rates specified on the label may adversely affect reproduction (USEPA 1996). As part of the RED, USEPA requires avian reproduction studies. These studies used northern bobwhite (*Colinus virginianus*) and mallard duck and revealed that cracked eggs were the common endpoint affected (USEPA 1996).

Data from invertebrate samples demonstrate the potential for DDE and trifluralin to bioaccumulate in the tissues of soil invertebrates and be introduced into the diet of mountain plovers while wintering in Imperial Valley.

Table 5. Arithmetic mean and range of concentrations of the most frequently detected organics[1] (ng/g dry weight) in invertebrate samples collected from mountain plover wintering sites in California, 2006.

Location and samples		PCB# 28	PCB# 72	PCB# 138/160	PCB# 172	PCB# 175	PCB# 180	PCB - total (Σ congeners)	p,p'-DDE	Total DDT	Trifluralin
Imperial Valley	ave	12.4	19	17.2	6.97	20.2	5.51	222	322	359	98.3
Off-refuge	min	8.76	2.35	8.62	0.85	10.6	3.06	45.9	137	158	<16.0
J20A - E (N=5)	max	20.8	32	26.2	12.0	32.1	11.7	767	478	537	256
Imperial Valley	ave	18.0	39	17.3	15.4	16.8	3.18	129	732	759	83.4
Off-refuge	min	11.6	1.02	7.66	5.09	7.57	1.09	92.3	222	264	<11.3
J22A - E (N=5)	max	34.1	65	23.8	22.0	28.7	8.35	152	1,310	1,337	252
Imperial Valley	ave	5.47	7.83	6.50	5.30	4.64	1.57	62.5	120	130	69.1
Off-refuge	min	4.21	0.320	4.53	2.19	1.77	0.63	38.9	47.8	62.3	35.30
K18A-E (N=5)	max	6.81	17	8.54	7.13	7.80	2.50	86.3	310	320	157
Imperial Valley	ave	5.93	6.81	6.84	4.44	6.05	1.24	64.3	306	324	<6.11
On-refuge; SBSS NWR	min	3.92	0.371	5.18	2.56	4.52	0.417	34.1	142	151	<4.17
SB420A - E (N=5)	max	7.58	22.9	8.36	6.19	8.80	2.94	95.1	547	575	9.13
Central Valley	ave	22.1	nd	11.6	3.40	14.2	3.44	178	10.2	38.5	<11.6
On-refuge; Kern NWR	min	10.5	nd	2.10	0.62	7.77	0.62	45.9	3.10	18.6	<6.08
K15A - E (N=5)	max	39.8	nd	20.7	8.95	22.7	6.55	604	17.2	63.0	<22.4

[1]See Appendix 5 for complete list of organic constituent concentrations by sample.

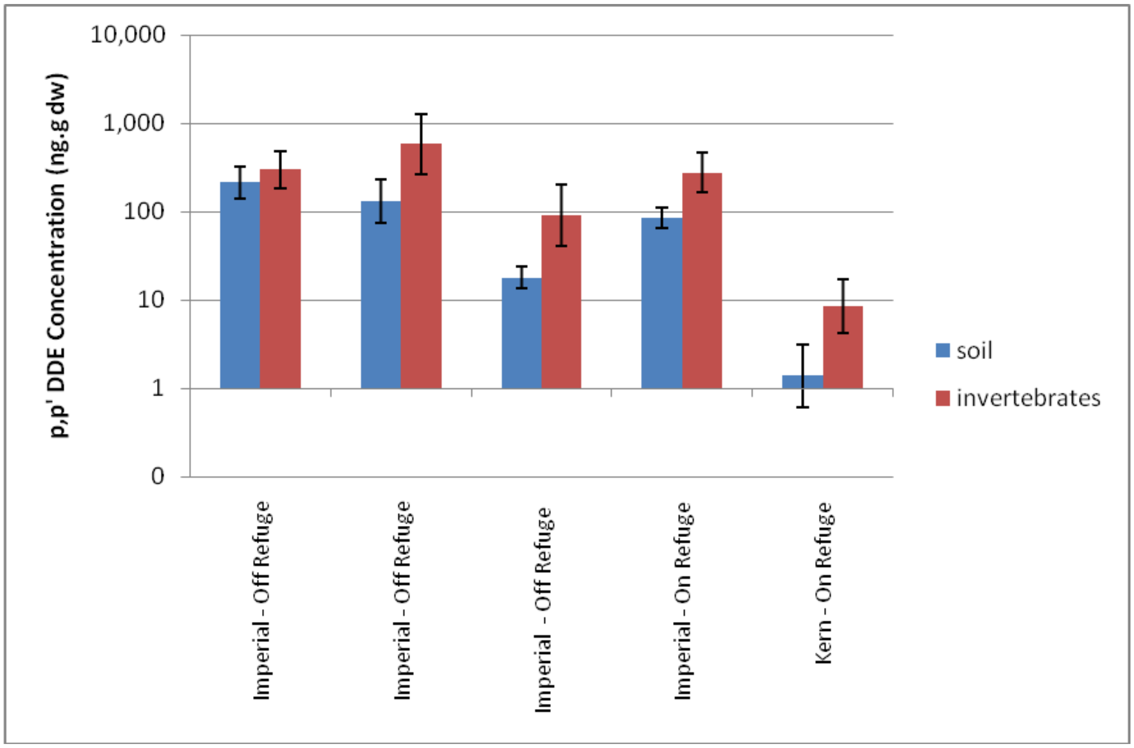

Figure 17. DDT isomer p,p'-DDE concentrations in soils and invertebrates collected in California.

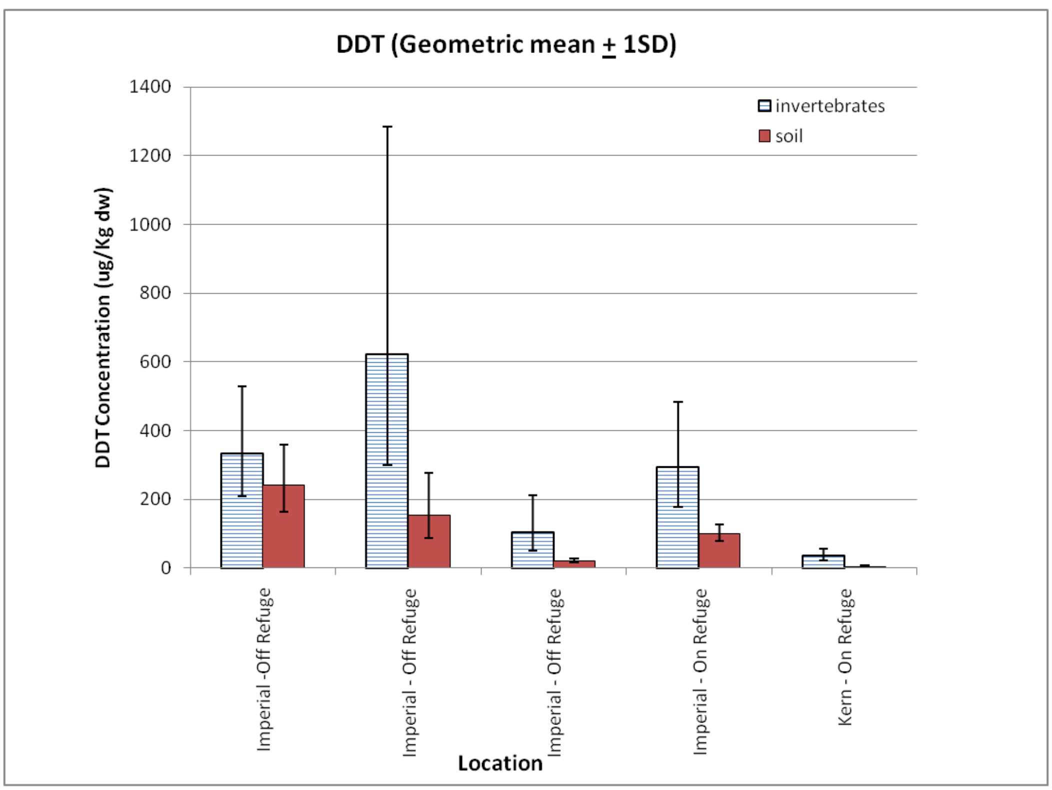

Figure 18. Total DDT concentrations in soils and invertebrates collected in California.

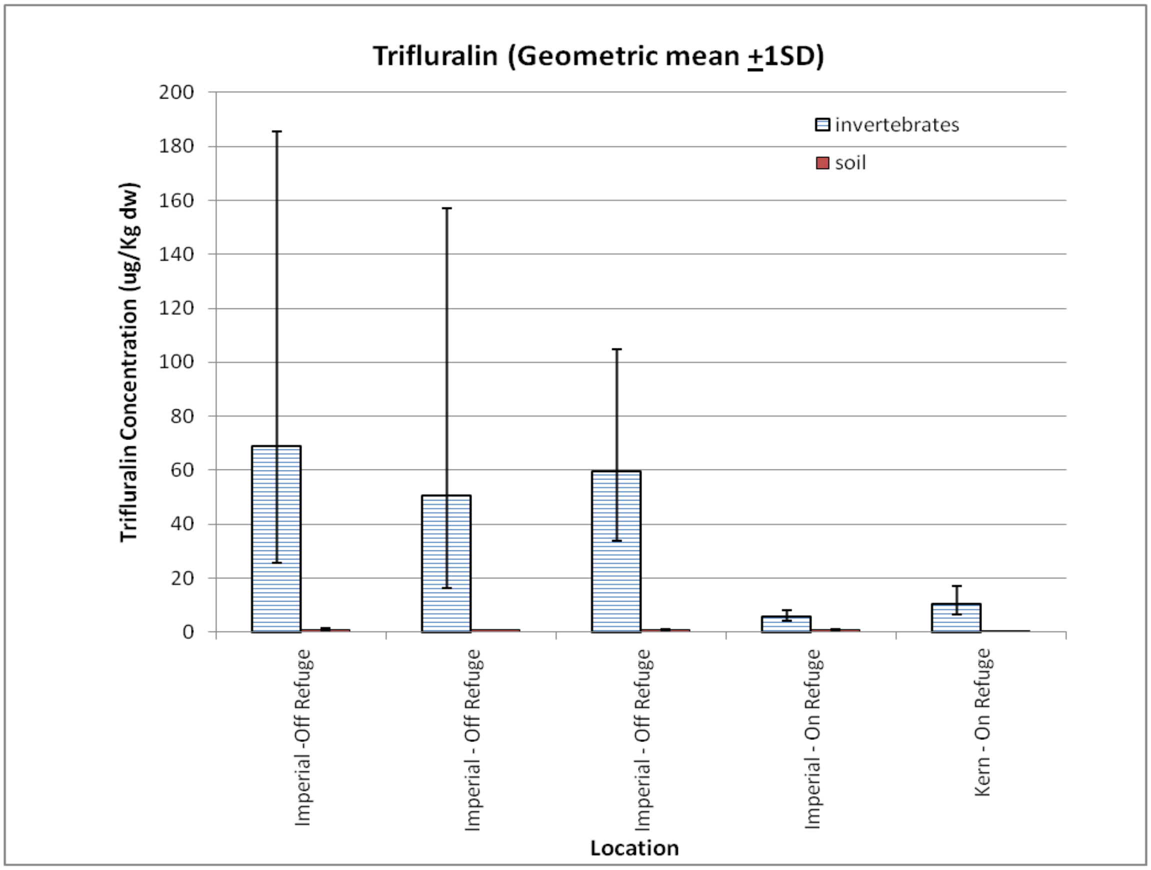

Figure 19. Trifluralin concentrations in soils and invertebrates collected in California.

Endosulfan II and endrin were both detected in one invertebrate sample from Kern NWR at levels considerably higher than the other Kern NWR invertebrates samples (all below non-detect) and those from Imperial Valley, including SBSS NWR (Appendix 5). Endosulfan does not accumulate in warm blooded animals indicating a low risk to the mountain plover (Wiemeyer 1996), however endrin is considered one of the most acutely toxic OCs (Blus 1995). Endrin was detected at a low concentration of 0.203 ng/g dw in the corresponding soil sample but the invertebrate sample contained 1,020 ng/g dw indicating significant bioaccumulation and a potential risk to mountain plovers consuming these invertebrates.

The total PCB concentrations in invertebrates ranged from 6 ng/g dw to 768 ng/g dw (Appendix 6). The median for all 25 samples was 138 ng/g dw and all but two samples had concentrations greater than 155 ng/g dw. These concentrations fell below dietary levels associated with most adverse reproductive effects in gallinaceous birds, which tend to be among the most sensitive of the avian receptors to PCB toxicity (USEPA 1995). These concentrations were also below 2,000 ng/g identified by USEPA (1995) as a NOAEL for multiple reproductive endpoints in gallinaceous species. Additionally, USEPA (1995) noted that 2,000 ng/g dw is a LOAEL for the most sensitive effect (reduced chick growth) among chickens exposed to most toxic PCB mixtures (Aroclors 1248 and 1254). Using an uncertainty factor of 10, the corresponding estimated NOAEL would be 200 ng/g dw, which is greater than concentrations observed in all but two samples of invertebrates.

Total PCB concentrations in the invertebrate samples were routinely higher than total PCB concentrations in co-located soil samples. However, the variation among samples was high so that site-specific differences or correlations with total PCB concentrations in soils, if present, could not be detected. Some of the variability observed with PCBs in invertebrate samples may be due to the nature of the samples, as each had different proportions of spiders, beetles, ants, and larvae. As a result, samples with more spiders may have had a higher concentration of PCBs, as some bioconcentration of PCBs within the invertebrate community had likely already occurred.

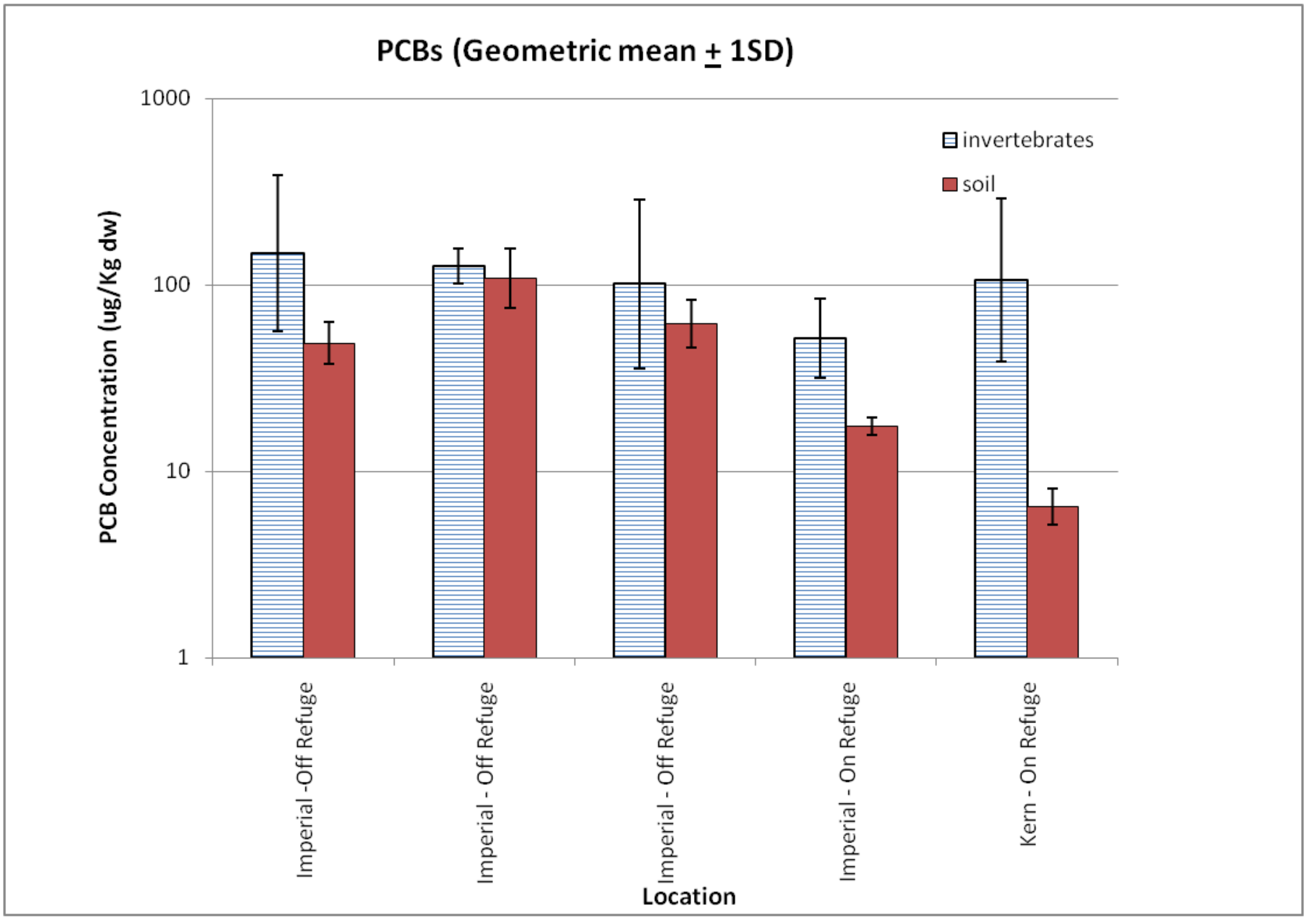

Figure 20. Concentration of total PCBs in soil and invertebrate samples collected in California.

Breeding Grounds

Soil-Inorganic Elements

Soil samples were collected from three refuges in Montana, three locations in Wyoming, and one location in Colorado. Soil trace element concentrations for all sites were lower than the Eco-SSLs for arsenic, beryllium, chromium, cobalt, and manganese. In addition, the average boron, barium, beryllium, chromium, mercury, molybdenum, and strontium in soil samples from breeding areas were either below or near the western U.S. average for background soils (Shacklette and Boerngen 1984). One composite soil sample from CMR NWR was the only site that had elevated concentrations of several trace elements in comparison to other sites sampled in the breeding area. Summary statistics of these inorganic element concentrations are contained in Table 6; full analytical results are listed in Appendix 7.

In soil samples from Montana sites, arsenic concentrations (range = 8.2 – 12.4 ug/g dw) were generally higher than average (5.5 ug/g dw) but within the range (<0.10 – 97 ug/g dw) for western U.S. background soils (Shacklette and Boerngen 1984) and did not exceed the Eco-SSL of 43 ug/g for the protection of birds or soil invertebrates (Table 6). Arsenic concentrations from Wyoming soil samples (range = 2.9 – 5.3 ug/g dw) centered around the western U.S. average (Shacklette and Boerngen 1984).

The average background concentration for cobalt in western U.S. soils is 7.1 (range = <3 – 50 ug/g dw). Six of the nine composite soil samples taken, primarily in Montana, were above this average (range = 7.4 – 23.2 ug/g dw) but all fell below the Eco-SSL of 120 ug/g for the protection of birds. Cobalt makes up part of vitamin B_{12} and is an essential micronutrient for animals including birds. Cobalt deficiency is typically more of a problem and studies on the effects of excess concentrations on birds are few (Nelson et al. 1966). However, comparison with the Eco-SSL suggests that risks posed to mountain plovers by cobalt concentrations in soils are likely to be low.

While Shacklette and Boerngen (1984) provide no values for background concentrations of cadmium in U.S. soils, the cadmium concentrations measured in soils from plover breeding sites (range = 0.13 – 1.1 ug/g dw) fell within the range of mean concentrations reported by Baudo et al. (1990) for soils uninfluenced by obvious sources (0.01 – 2 ug/g dw). Only one soil sample exceeded the Eco-SSL for avian wildlife (0.77 mg/kg dw), which is based on the woodcock, a ground insectivore (USEPA 2005d). The composite soil sample collected from North and South Buckskin Ridge on CMR NWR contained 1.09 mg/kg dw. Laboratory studies suggest that dietary intake of <1 mg/kg cadmium in food would not lead to any toxicological effect in birds (Furness 1996).

Copper concentrations in soils from breeding sites ranged from 6.7 ug/g dw to 30 ug/g dw, which were higher than the average of 2.07 ug/g, but within the range (2 – 300 ug/g dw) reported by Shacklette and Boerngen (1984) for western U.S. soils. These concentrations, with the exception of a soil sample from ACM study area in Wyoming (30 ug/g dw), also fell below the Eco-SSL of 28 ug/g for protection of avian species and all were below the Eco-SSL of 80 ug/g for protection

Table 6. Average and range of concentrations of select inorganics[1] (ug/g dry weight) in soil samples collected from mountain plover breeding sites[2] in Montana and Wyoming, 2006, for comparison with average and range of inorganics in soils from the western United States as reported by Shacklett and Boerngen (1984).

		As	B	Ba	Be	Cd	Co	Cr	Cu	Hg	Mn	Mo	Ni	P
WY - Soil (n=3)	average	4.29	4.96	112	0.60	0.32	6.61	15.9	23.4	0.04	179	BDL	19.81	358
	minimum	2.9	BDL[3]	88.4	0.393	0.27	5.0	8.58	18.1	0.014	97.8	BDL	9.12	272
	maximum	5.32	4.96	148	0.972	0.394	8.15	22.1	30	0.07	288	BDL	33.7	402
MT - Soil (n=5)	average	10.0	12.42	229	0.79	0.48	12.23	23.1	18.7	0.02	826	0.58	23.94	704
	minimum	8.18	9.41	115	0.626	0.274	7.4	21.1	16.5	0.020	426	BDL	17.8	591
	maximum	12.4	14.2	363	0.988	1.09	23.2	25.6	20.6	0.028	2290	0.99	40.8	863
western U.S. background soils	average	5.5	23	580	0.68	No value	7.1	41	2.07	0.46	380	0.85	15	320
	minimum	<0.10	<20	70	<1		<3	3	2	<0.01	30	<3	<5	40
	maximum	97	300	5000	15		50	2000	300	4.6	5000	7	700	4500

		Pb	Se	Sr	V	Zn
WY - Soil (n=3)	average	11.51	0.56	45.97	31.13	54.17
	minimum	8.14	0.204	17.9	22.7	38.1
	maximum	17.1	1.22	95.2	37.3	80.6
MT - Soil (n=5)	average	13.68	0.46	51.20	55.26	77.16
	minimum	12.4	0.262	24	41.1	65.1
	maximum	15.1	0.589	109	65.6	84.9
western U.S. background soils	average	17	0.23	200	70	55
	minimum	<10	<0.1	10	7	10
	maximum	700	4.3	3000	500	2100

[1]See Appendix 7 for complete list of inorganic constituent concentrations by sample.
[2]Only one soil sample collected from the Colorado mountain plover breeding site so data are not presented in this table.

[3]BDL = Below Detection Limit

of soil invertebrates. Copper is an essential nutrient and deficiency or excess can be harmful to organisms. Reports of toxic effects from excess dietary exposure in birds in field conditions are rare (Eisler 1997; USDOI 1998).

The average lead concentrations in soil samples from breeding areas were below the average background concentration of 17 ug/g for western U.S. soils (Shacklette and Boerngen 1984), but most individual samples exceeded the Eco-SSL of 11 ug/g (Table 1). The likelihood of poisoning from the ingestion of lead in forms other than spent ammunition or where soil is extremely contaminated from mining operations is slim (Eisler 1988b).

Manganese in soil samples from Montana were above the average of 380 ug/g for western U.S. soils with one on-refuge soil sample having a high value of 2,290 ug/g dw (Table 6; Appendix 7). Even so, this high concentration is below the Eco-SSL 4,300 ug/g and is of little concern (Table 1).

Nickel concentrations (range = 16.6 – 40.8 ug/g dw) were slightly above the average (15 ug/g) for western U.S. soils in seven of nine soil samples from breeding grounds but below the Eco-SSLs for birds (210 ug/g) and soil invertebrates (280 ug/g). Nickel does not biomagnify and even in areas near smelters where nickel is significantly elevated in soils, it is unlikely that higher trophic level species are affected (Phipps et al. 2002).

Phosphorus was above the average (320 ug/g) for western U.S. soils for all soil samples in the breeding areas except one sample from TBNG in Wyoming (Table 6; Appendix 7). The availability of phosphorus depends on a soil's pH, with a lower pH increasing aluminum's solubility. The aluminum then readily binds to phosphorus making it unavailable to birds. Phosphorus is an essential element for eggshell development and bone growth (Miles et al. 1993). Western U.S. soils are primarily alkaline thereby reducing the availability of phosphorus to birds (Miles et al. 1993).

Selenium concentrations in breeding area soil samples (range = 0.2 – 1.22 ug/g dw; average = 0.459) were mostly above the average of 0.23 ug/g dw for background western U.S. soils

(Shacklette and Boerngen 1984), but appear to be typical for native rangeland soils sampled in parts of Wyoming and Montana (0.061 – 3.3 ug/g; Tidball 1976). Because selenium is very mobile in alkaline soils, geological formations in the western U.S. readily contribute selenium to the soils (USDOI 1998). Although, selenium is an essential mineral for organisms, there is a small margin between what is required nutritionally and what is considered toxic. These background concentrations are slightly lower than the avian insectivore Eco-SSL of 1.2 mg/kg dw in soil. Only one soil sample from ACM exceeded this level with a concentration of 1.22 mg/kg dw. Because the Eco-SSL is based on a no-effect level, dietary ingestion of selenium from soils is not likely to cause any impacts to mountain plovers on their breeding grounds based on the samples collected as a part of this investigation, or to soil invertebrates, which plovers rely on for food (Eco-SSL 4.1 ug/g dw; Table 1).

Vanadium concentrations in all soil samples were below the average background of 70 ug/g dw for western U.S. soils (Shacklette and Boerngen 1984), but above the Eco-SSL of 7.8 ug/g dw for the protection of birds. Whether the exceedances of Eco-SSLs translate into significant risk for mountain plovers is uncertain because the avian Eco-SSL is based on results from studies on chickens, and data on vanadium toxicity to wild species are lacking. Results of one study on waterfowl demonstrated that sensitivity to vanadium toxicity depends on the form of the vanadium and the species of the bird (Rattner et al. 2006).

Concentrations of zinc in soil samples (range = 65.1 – 84.9 ug/g dw) from Montana and one soil sample (80.6 ug/g dw) from Wyoming were above the average (55 ug /g dw) for background in western U.S. soils (Shacklette and Boerngen 1984), but were within the range of means reported by Kabata-Pendias and Pendias (1992) for uncontaminated sites (17 – 125 ug/g dw and rarely >200 ug/g dw). All Montana soils and the ACM in Wyoming sample exceeded the Eco-SSL for an avian insectivore (46 mg/kg dw). However, the extent to which the Eco-SSL was exceeded was small. The maximum zinc concentration of 85 ug/g dw was 1.8-fold greater than the Eco-SSL, which accounts for exposure through ingestion of soil and soil invertebrates that have accumulated zinc in their tissues. Zinc is an essential element and while it may be bioaccumulated by exposed invertebrates, the zinc concentrations measured in soils from breeding sites were not elevated enough be considered harmful by either direct (incidental ingestion) or indirect (dietary) exposure (Eisler 1993). Zinc is a required nutrient and bird diets should contain 25 – 38 mg/kg dw in feed to prevent the effects of zinc deficiency and 93 – 120 mg/kg dw for optimal growth (Eisler 1993).

Soils-Organic Compounds

OCs, OPs, and total PCBs (ng/g dw) were not detected in soil samples collected from mountain plover breeding sites in Colorado, Montana, and Wyoming in 2006. The specific compounds (and detection limits) for which all samples were analyzed are listed in Appendix 8.

Terrestrial Invertebrates-Inorganic Elements

Concentrations of inorganics in terrestrial invertebrates from breeding sites were typically lower than those found in terrestrial invertebrate samples collected from wintering sites in California (Table 7). Among breeding sites, one composite invertebrate sample from CMR NWR had higher concentrations of inorganic compounds than samples from the other sites. This is not surprising given that most of the inorganic elements in soil sampled from this same site were also higher than soil sampled from other sites (Appendices 7 and 9).

Aluminum concentrations in all but one of the terrestrial invertebrate samples (range = approximately 52 – 387 ug/g dw) were much lower than those collected from wintering grounds in California. The one exception is the composite sample from CMR NWR with an aluminum concentration of 2,180 ug/g dw. This concentration is far below the aluminum concentration of 5,000 ug/g considered to be the adverse dietary effect level in waterfowl (Sparling and Lowe 1996), but is above the 1,000 ug/g NOAEL developed for ring doves (*Streptopelia risoria*) (Sample et al. 1996).

Arsenic concentrations measured in invertebrates ranged from 0.07 ug/g dw to 2.15 ug/g dw. Dietary effects level of arsenic to birds depends on the arsenical compound and the bird species (USDOI 1998). For example, female mallard ducklings exhibited reduced growth when fed 30 ug/g dw as As^{+5} over a 10 week period (Eisler 1988a); whereas 99.8 ug/g dw of dietary sodium arsenate was lethal to 50 percent of the brown-headed cowbirds tested over an 11-day period

(Camardese et al. 1990). Concentrations measured in invertebrates consumed by plovers were all well below concentrations associated with adverse effects.

Barium concentrations in all but one of the terrestrial invertebrate samples from breeding grounds were below the estimated dietary NOAEL-based benchmark for avian wildlife of 20.8 ug/g (Sample et al. 1996). Beryllium was below detection limits for all samples except one in Montana and that concentration was very low (0.132 ug/g dw). Additionally, concentrations of boron, cadmium, chromium, and molybdenum observed in terrestrial invertebrates were low (Eisler 1985a, 1986, and 1989; Sample et al. 1996; USDOI 1998).

Cobalt concentrations were low in invertebrates collected (range = <0.45 – 0.84 ug/g dw) with the exception of one sample in Montana that had the maximum concentration 2.12 ug/g dw. It is unclear if this cobalt concentration could affect mountain plover because effects of dietary cobalt on birds are not well studied.

Copper concentrations in invertebrate samples ranged from approximately 14 ug/g dw to 48 ug/g dw. Unfortunately, little information exists on the dietary concentration of copper that may cause toxicity to wild birds. Information on poultry indicate that a diet with 300 ug/g of copper is the maximum tolerable limit, but concentrations found in terrestrial invertebrates from all mountain plover breeding sites were well below this level (Eisler 1997; USDOI 1998).

Mercury was detected in invertebrate samples but concentrations were low (range = <0.0047 – 0.017 ug/g dw) compared with concentrations reported in reviews such as Eisler (1987). Nickel concentrations ranged from <0.49 ug/g dw to 1.77 ug/g dw for all terrestrial invertebrate samples collected at breeding sites except the one sample from CMR NWR site (94.94 ug/g dw). There is little information on dietary nickel concentrations required for adverse effects in wild birds. However, the high concentration measured in the sample from CMR NWR was below the nickel concentration found to affect domestic chickens (<700 ug/g dw; Weber and Reid 1968) and mallard ducklings (<800 ug/g dw; Cain and Pafford 1981). Like nickel, the maximum concentration of lead was in the sample from CMR NWR (3.15 ug/g dw versus 0.135 – 0.866 ug/g dw), but this concentration is well below dietary effects levels for birds reported by Eisler

(1988b) at 50 ug/g inorganic lead and Hoffman et al. (1985) at >25 ug/g body weight (BW) or approximately 139 ug/g mountain plover diet. The selenium concentration (2.56 ug/g dw) in the invertebrate sample at the CMR NWR site was also higher than from invertebrates collected at the other sites (range 0.613 – 1.76 ug/g dw), but were below dietary effects levels for birds (>3 ug/g dw; USDOI 1998).

Strontium concentrations measured in invertebrates from plover breeding grounds were between 0.438 ug/g dw and 2.56 ug/g dw. Strontium is considered to have low toxicity to animals (Wennig and Kirsch 1950), although it is unknown if strontium levels measured in invertebrates at this site pose a threat to mountain plover. Dietary concentrations between 8 ug/g dw and 117 ug/g dw have been related to elevated levels in egg contents and shells of passerine birds in Arizona (Mora 2003) but samples from the mountain plovers' breeding sites were at the lower end of this range.

Titanium concentrations ranged from 5.8 us/g dw to 27.3 ug/g dw. The effect of titanium in the diet of birds is unknown. Similarly, information on the toxicity of dietary vanadium to terrestrial birds is limited. Results of studies by Rattner et al. (2006) on mallards and Canada geese indicate that dietary effect levels vary, depending on the form of the vanadium, but also that dietary concentrations of 250 ug/g caused little known toxicity. Vanadium concentrations measured in invertebrates (maximum = 7.7 ug/g dw) are well below published adverse effect levels for mallards and Canada geese. Concentrations of zinc ranged from 85.8 ug/g dw to 169 ug/g dw, which are below zinc dietary levels of 178 ug/g that cause immunosuppression in young domestic chickens following subchronic exposure of three weeks (Eisler 1993).

Table 7. Average and range of concentrations of select inorganics[1] (ug/g dry weight) in invertebrate samples collected from mountain plover breeding sites in Colorado, Montana, and Wyoming, 2006.

		Al	As	Ba	Co	Cu	Hg	Ni	Pb	Se	Sr	Ti	V	Zn
WY - Insects (n=5)	average	108.8	0.18	8.57	0.48	23.96	0.006	1.32	0.25	0.66	9.4	7.2	0.399	125.4
	minimum	52.8	0.07	5.85	0.46	18.3	BDL	0.83	0.14	0.44	5.8	5.9	BDL	111
	maximum	183	0.41	11.8	0.51	28	0.007	1.77	0.34	0.75	17.8	9.8	0.682	137
MT - Insects (n=5)	average	631.5	0.88	18.1	0.81	30.44	0.011	1.9	0.99	1.39	20.9	15.5	2.31	153.6
	minimum	90.3	BDL[2]	9.68	BDL	17.1	0.007	0.83	0.21	0.68	10.1	2.9	BDL	137
	maximum	2180	2.15	42.6	2.12	47.5	0.017	4.94	3.15	2.56	31	43	7.77	169
CO - Insects (n=2)	average[3]													
	minimum	101	0.09	6.93	0.47	14.1	BDL	BDL	0.23	0.61	6.2	6.7	BDL	85.5
	maximum	134	0.11	9.18	0.49	23.6	BDL	0.62	0.33	0.68	7.5	9.4	BDL	104

[1]See Appendix 9 for complete list of inorganic constituent concentrations by sample.
[2]BDL = Below Detection Limit
[3]Average not calculable as n=2

Terrestrial Invertebrates-Organic Compounds

None of the target organic analytes (OCs, OPs, and total PCBs) was detected in terrestrial invertebrate samples collected from mountain plover breeding sites in 2006 from Colorado, Montana, or Wyoming. Specific compounds analyzed in terrestrial invertebrate samples are listed in Appendix 10.

Mountain Plover Eggs-Inorganic Elements-2006

Generally, concentrations of most inorganic constituents were low in mountain plover eggs. Boron, beryllium, cobalt, chromium, molybdenum, and vanadium were not detected in any of the mountain plover eggs collected in 2006. Silver was not analyzed in eggs collected in Montana and was not detected in any eggs collected from Colorado or Wyoming. Arsenic was detected in more than half the eggs collected (Table 8; Appendix 11), but at concentrations below the tentative screening level of 1.3 ug/g dw for no effects in birds (USDOI 1998).

Barium concentrations measured in mountain plover eggs (range = 3.15 ug/g – 19.6 ug/g dw; Table 9) were above levels found in the yellow-breasted chat (*Icteria virens*) (2.5+2 ug/g dw) and the endangered southwestern willow flycatcher (*Empidonax traillii extimus*) (0.5 + 0.1 ug/g dw) from Arizona (Mora 2003). In eggs of the California clapper rail (*Rallus longirostris obsoletus*) collected in the south and north sections of San Francisco Bay averaged 0.34 ug/g dw (max 0.59 ug/g dw) and 0.45 ug/g dw (max 4.13 ug/g dw), respectively (Schwarzbach et al. 2006). Three of the clapper rail embryos exhibited deformed feet where barium concentrations ranged from 2.2 ug/g dw to 4.1 ug/g dw. Such high barium concentrations may possibly be associated with malpositioning in late stage embryos (Schwarzbach et al. 2006). Of the 20 mountain plover eggs collected, only one embryo (age 25 days) from Wyoming was deformed. This embryo exhibited an abnormally small head and an upper bill that twisted out and up. The barium concentration in that egg was 13.1 ug/g dw, which is greater than the barium concentration found in deformed California clapper rail embryos. However, whether the deformed mountain plover is the result of the elevated barium concentration is unknown as three eggs from PNG had higher barium concentrations than the egg with the deformed chick and these did not appear to have deformities when examined.

Table 8. Average and range of concentrations of inorganics[1, 2] (ug/g dry weight) in egg samples[3] collected from mountain plover breeding sites in Colorado, Montana, and Wyoming, 2006.

Location	Parameter	Moisture %	Al ug/g dw	As ug/g dw	Ba ug/g dw	Ca ug/g dw	Cu ug/g dw	Fe ug/g dw	Hg ug/g dw
Pawnee National Grasslands, CO (n=5)	average	72.66	1.15	0.13	14.60	5538.00	3.05	111.46	0.037
	minimum	71	0.68	0.05	10.5	2680	2.23	96.3	0.026
	maximum	74.7	1.47	0.22	19.6	9900	4.29	136	0.051
BLM Lands, Phillips County, MT (n=7)	average	72.61	0.71	0.18	8.12	7394.29	3.18	106.11	0.035
	minimum	70.3	0.54	0.18	5.75	2680	2.66	84.9	0.025
	maximum	75.9	0.89	0.19	9.72	19200	4.13	126	0.049
Foote Creek Rim, WY (n=5)	average	72.6	0.82	0.11	4.86	5898	2.824	88.3	0.052
	minimum	71.6	0.62	0.05	3.15	2750	2.65	77.4	0.039
	maximum	74.3	1.19	0.29	5.85	13500	3	97.7	0.075

Table 8. cont.

Location	Parameter	K ug/g dw	Mg ug/g dw	Mn ug/g dw	Na ug/g dw	Ni[4] ug/g dw	P ug/g dw	Pb ug/g dw	S ug/g dw
Pawnee National Grasslands, CO (n=5)	average	5300	481	1.55	5254	22.06	8958	0.06	6294
	minimum	4490	371	0.96	4490	1.15	7920	BDL[5]	5420
	maximum	6310	590	2.14	6190	55.7	9810	0.19	6840
BLM Lands, Phillips County, MT (n=7)	average	5582.86	559.71	1.27	5928.57	NC[6]	8588.57	0.06	7596
	minimum	4700	403	0.67	5200	BDL	7380	BDL	6670
	maximum	6350	922	2.05	7310	BDL	10900	0.13	9070
Foote Creek Rim, WY (n=5)	average	5328	507.8	1.29	5352	NC	8612	0.03	6744
	minimum	4620	401	0.907	4520	BDL	7810	BDL	5920
	maximum	5730.00	748.00	1.83	6570.00	BDL	10300	0.05	7650

T`able 8. cont.

Location	Parameter	Se ug/g dw	Si ug/g dw	Sr ug/g dw	Ti ug/g dw	Zn ug/g dw
Pawnee National Grasslands, CO (n=5)	average	2.89	11.59	7.87	0.54	51.88
	minimum	2.19	9.77	3.81	BDL	39.7
	maximum	3.84	12.9	13.5	1.06	60
BLM Lands, Phillips County, MT (n=7)	average	4.87	NA	8.49	NC	45.37
	minimum	3.64	NA	2.74	BDL	36.5
	maximum	7.32	NA	16.60	BDL	52.9
Foote Creek Rim, WY (n=5)	average	2.64	8.96	7.75	0.61	52.5
	minimum	2.16	8.03	3.63	BDL	43
	maximum	3.1	9.93	17.1	1.78	60.2

[1]See Appendix 11 for complete list of inorganic constituent concentrations by sample.

[2]One sample at Pawnee National Grasslands, CO had a Cd concentration of 0.021 ug/g dw; the other four samples were below the detection limit. All BLM Lands, MT samples and all Foote Creek Rim, WY samples were below the detection limit for Cd.

[3]One egg collected from Charles M. Russell NWR, MT and two egg samples collected from the Antelope Coal Mine site, WY are not included in this table but are addressed in the text if the inorganic element concentration is elevated.

[4]One sample at Foote Creek Rim, WY had a Ni concentration of 0.67 ug/g dw; the other four samples were below the detection limit. All BLM Lands, MT samples were below the detection limit for Ni.

[5]BDL = Below Detection Limit.

[6]NC = Not calculable.

Table 9. Barium concentrations and developmental stage of mountain plover eggs collected from breeding sites in Colorado, Montana, and Wyoming in 2006.

Location	Sample	Barium ug/g dw	Fertile	Age days	Abnormal
Pawnee National Grasslands, CO	MPWCPE01	10.8	Yes	8	No
Pawnee National Grasslands, CO	MPWCPE02	13.7	Yes	4	No
Pawnee National Grasslands, CO	MPWCPE03	18.4	Yes	24	No
Pawnee National Grasslands, CO	MPWCPE04	19.6	Yes	12	No
Pawnee National Grasslands, CO	MPWCPE05	10.5	Yes	17	No
BLM Lands, Phillips County, MT	BLM025MPE	7.83	Yes	10	No
BLM Lands, Phillips County, MT	BLM081-2MPE	8.83	*	*	*
BLM Lands, Phillips County, MT	BLM081MPE	9.37	*	*	*
BLM Lands, Phillips County, MT	BLM189MPE	5.75	*	*	*
BLM Lands, Phillips County, MT	BLMB026MPE	6.71	Yes	15	No
BLM Lands, Phillips County, MT	BLMS014MPE	8.65	Yes	15	No
BLM Lands, Phillips County, MT	BLMS020MPE	9.72	*	*	*
Charles M. Russell NWR, MT	CMRNMCMPE06	10	**	Fresh	No
Near Antelope Coal Mine, WY	MPAMPE01	5.2	Yes	9	No
Near Antelope Coal Mine, WY	MPAMPE02	13.1	Yes	25	Yes
Foote Creek Rim, WY	MPFCPE01	4.86	Yes	21	No
Foote Creek Rim, WY	MPFCPE02	4.97	Yes	21	No
Foote Creek Rim, WY	MPFCPE03	3.15	No	0	No
Foote Creek Rim, WY	MPFCPE04	5.85	Yes	25	No
Foote Creek Rim, WY	MPFCPE05	5.49	Yes	10	No

* Egg collected from abandoned nest, and yolk in advanced state of decay
** Fertility not noted

Cadmium was not detected in most eggs except one egg from the ACM site (0.065 ug/g dw) and one egg from PNG (0.021 ug/g dw; Appendix 11). According to Ohlendorf (1993), non-toxic concentrations of cadmium in avian eggs are <0.5 ug/g. The toxic effects most commonly associated with cadmium exposure include impaired growth, anemia, and testicular damage (Eisler 1985a). The toxic effects of cadmium in avian species have also included altered avoidance response, reduced egg production, eggshell thinning, kidney damage, damage to the gut epithelium, altered energy metabolism, impaired bone marrow function, heart abnormalities, and adrenal abnormalities (Eisler 1985a; Furness 1996). These effects, which were observed in laboratory tests, have been related to cadmium levels in the diet, the liver, or the kidney. Benchmarks relating adverse effects of cadmium concentrations in eggs are lacking (Ohlendorf 1993) and the likelihood of cadmium reaching these adverse levels in eggs is considered to be very low (Furness 1996).

Copper was detected in eggs, but all below the tentative screening level of 5.5 ug/g dw eggs (USDOI 1998). Similarly, mercury was detected in all egg samples, with a maximum of 0.075 ug/g dw (or 0.021 ug/g ww for that sample). The level of concern for mercury in eggs is between 0.2-1.0 ug/g ww (USDOI 1998) and a level of 0.5 ug/g ww in eggs (or about 2.5 ug/g dw assuming 80% egg moisture) does not appear to have any adverse effects on reproduction (Thompson 1996).

Lead was detected in nine of 20 eggs. Concentrations in all of the eggs were less than 0.5 ug/g dw, which is consistent with concentrations of <0.5 ug/g dw reported for eggs of yellow-breasted chat and willow flycatchers (Mora 2003), and what is considered background (<1.0 ug/g dw; Ohlendorf 1993; Gochfeld and Burger 1998).

Nickel was below the detection limit in most eggs from Colorado, Montana, and Wyoming. One egg collected at FCR, Wyoming, had a detectable nickel concentration of 0.67 ug/g dw. Interestingly, all eggs collected at PNG had detectable nickel concentrations (1.2, 4.1, 14.4, 35, and 55.7 ug/g dw). It is unknown what the source of the elevated nickel concentrations is because the corresponding soil sample and invertebrate diet sample analyzed from this site and from the California wintering sites did not show elevated nickel concentrations. Nickel is toxic and teratogenic in domestic chickens at concentrations in eggs as low as 0.02 mg/egg (approximately 2.0 ug/g dw assuming a 55 g/egg with 80% moisture; Eisler 1998). Studies where nickel concentrations of 700 ug/g as nickel mesotetraphenylporphine in 1 uL of crude oil (= 0.7 ug per egg or ~0.06 ug/g dw assuming 60 g/egg and 80% moisture) injected into mallard duck eggs did not affect embryo survival significantly compared to eggs where just 1 uL of crude oil was injected, although the embryonic weight was significantly lower, and the percentage of abnormalities in post hatch survivors was increased (Hoffman 1979). The potential for toxicity depends on the form that the nickel is in and the species of the exposed organism. Nickel concentrations measured in mountain plover eggs from PNG (average = 22 ug/g dw) are greater than concentrations associated with adverse effects in other species, and as such, may be at levels of concern for the plover. No abnormalities were noted, however.

Bird eggs collected from study sites not impacted by selenium usually contain $\leq$3 ug/g dw with a maximum of 5 ug/g dw (USDOI 1998). The average selenium concentrations in eggs from PNG (2.89 ug/g dw), FCR (2.64 ug/g dw), and the one egg collected near the ACM site (3.03 ug/g dw) were at or below the mean background concentration. Selenium concentrations in one egg from CMR NWR (3.63 ug/g dw) and most of the eggs collected from BLM lands in Montana were above average background, but within the range of background samples (Table 8). Three eggs collected on the BLM lands were >5 ug/g dw but still below the embryotoxic threshold for selenium in bird eggs of 10 ug/g dw (Heinz 1996). The reasons as to why selenium concentrations in eggs from Montana were higher than in eggs from Colorado and Wyoming are not clear because selenium concentrations in co-located soil and invertebrate samples from the Montana site tended to be lower in selenium than concentrations in soils and invertebrates from Wyoming and from wintering sites in the Imperial Valley (Tables 2, 4, 6, and 7). Because ingested selenium is readily transferred from the female bird to the egg (Eisler 1985c), the apparent higher levels in eggs from the Montana sites may be the result of incidental soil ingestion (USDOI 1998). The suggested embryotoxic threshold for selenium in bird eggs is estimated to be 10 ug/g (Heinz 1996; USDOI 1998).

Concentrations of sulfur and silicon are reported for mountain plover egg contents, but the significance of the concentrations is not known. Research on domestic chickens indicates that a laying hen will deposit sulfate in the egg and that some of this will be converted into the amino acid cystine (Machlin et al. 1953). Silicon is considered an essential nutrient for animals in small quantities (Ohlendorf 1993). However, concentrations that may be associated with adverse effects have not been identified.

Strontium concentrations in plover eggs did not appear elevated when compared with levels in eggs of the yellow-breasted chats (mean = 23.9 $\pm$ 12.7 ug/g dw) and willow flycatchers (mean = 35.1 $\pm$ 58 ug/g dw) in Arizona (Mora 2003) or with normal embryos of California clapper rail (mean = 66.1 ug/g dw; range 30.2 – 94.6 ug/g dw; Schwarzbach et al. 2006). Titanium concentrations in plover eggs were low or below the detection limit. The significance of titanium in avian egg contents in unknown.

Average zinc concentrations in mountain plover eggs from PNG (51.98 ug/g dw; range 39.7 – 60.0 ug/g dw) and FCR (52.5 ug/g dw; range 43.0 – 60.2 ug/g dw) were slightly above what is considered background for avian eggs in general (50 ug/g dw; USDOI 1998). The one egg from ACM had the highest zinc concentration (64.1 ug/g dw) of any of the eggs collected from the breeding areas, and eggs from Montana (range 36.5 – 52.9 ug/g dw) were less than- to slightly higher than background. The significance of observed zinc concentrations on the development of mountain plover is not known, but zinc is an essential element whose mobilization and transfer from storage sites to the developing embryo is regulated during development (Richards 1997).

Because of the generally overall low concentrations of inorganic elements in egg samples from 2006, and to control costs, eggs collected in 2007 and 2008, and archived eggs collected in 2003 were analyzed for organic constituents only.

Mountain Plover Eggs-Organic Compounds-2006

Overall, very few organic compounds were detected in any of the mountain plover eggs sampled from Colorado, Montana, and Wyoming (Appendix 12). Hexachlorobenzene (HCB) was detected at low concentrations in mountain plover eggs with the highest concentration (32.5 ng/g dw) detected in an egg from PNG (Table 10; Appendix 12). HCB was used as a fungicide to treat crop seeds but banned in 1965 in the U.S because of its carcinogenic properties. In 1995, it was banned globally at the Stockholm Convention because, as a persistent organic pollutant, it is observed to have long-range transport, significant human health and environmental effects, biomagnifies up the food chain, and degrades very slowly (half-life of 3 to 6 years in soil; ATSDR 2002). HCB is lipophilic and is primarily acquired by ingesting contaminated food items. In birds, females pass HCB directly into the egg (primarily the yolk) as shown in studies with Japanese and bobwhite quail (Ingebrigsten et al. 1981; Breslin et al. 1983). Little information exists on the effects of these concentrations on embryo survival and health but a levels of 80 ug/g (80,000 ng/g) or higher was necessary before reproductive failure occurred in Japanese quail (Bechard 1981). Therefore, the concentrations of HCB found in the mountain plover eggs are unlikely to affect the embryos.

Table 10. Average and range of concentrations of most frequently detected organochlorine compounds[1] (ng/g dry weight) in egg samples collected from mountain plover breeding sites in Colorado, Montana[2] and Wyoming, 2006.

Location	Parameter	HCB ng/g dw	oxychlordane ng/g dw	p,p'-DDE ng/g dw
Pawnee National Grasslands, CO (n=5)	average	15.4	18.4	13,062
	minimum	7.52	BDL	46.8
	maximum	32.5	48.8	43,200
BLM Lands, Phillips County, MT (n=7)	average	8.24	6.92	3,990
	minimum	BDL	BDL	134
	maximum	16.7	25.1	18,600
Foote Creek Rim, WY (n=5)	average	5.6	NC	1,328
	minimum	BDL	BDL	45
	maximum	8.4	BDL	4,090

[1]See Appendix 12 for complete list of organic constituent concentrations by sample including those constituents not detected in any mountain plover egg sample.
[2]One egg collected from Charles M. Russell NWR, MT and two egg samples collected from the Antelope Coal Mine site, WY are not included in this table but are addressed in the text if the organic element concentration is elevated.
[3]BDL = Below Detection Limit.
[4]NC = Not calculable.

Oxychlordane was detected primarily in eggs collected from Colorado (Table 10; Appendix 12) with the highest concentration (48.4 ng/g dw) in the same egg that exhibited the highest concentration of HCB. Oxychlordane is a metabolite of chlordane, which was used primarily for the control of various crop pests and termites. All uses of chlordane were banned in the U.S. in 1988. Oxychlordane is more lipophilic, toxic, and persistent than chlordane (Eisler 1990a). Unfortunately, there is little information on the levels of oxychlordane in eggs that might be associated with adverse effects, and consequently, the implications of concentrations observed in plover eggs are not known.

DDE was detected in all eggs collected from all breeding sites (Table 10; Appendix 12). DDE is a major metabolite of the insecticide DDT, which was banned in 1972 in the U.S. DDE is still commonly found in the environment because of its persistence as well as atmospheric transport and deposition from other countries which continue to use DDT (DOI 1998). Although no DDT or DDT metabolites were found in any soil or invertebrate samples collected on the breeding grounds in Montana, Wyoming, or Colorado, it was still detected in both soil and invertebrate samples collected in plover wintering grounds. Since little to no exposure to DDE occurs on mountain plover breeding grounds sampled as part of this investigation, it appears that DDE deposited in eggs of mountain plovers was from exposures on their wintering grounds.

DDE, specifically p,p'-DDE, is one of the metabolites responsible for deleterious effects in birds, with the most sensitive and most documented being eggshell thinning and subsequent breakage (Blus 1996). Much of the research on DDE's deleterious effect in terrestrial birds has focused on tissue residues (primarily brain and liver; Blus 1996), or concentrations of DDE found in the diet of these birds (USDOI 1998) rather than concentrations in eggs (with the exception of raptors), making it difficult to determine exactly what effects the concentrations of DDE observed in mountain plover eggs collected for this study may have. Even so, the concentrations of DDE in some of the individual plover eggs collected from this study were higher than 3 ug/g ww (3,000 ng/g ww) shown to cause almost complete colony failure due to egg breakage in the brown pelican (*Pelecanus occidentalis*), considered one of the most sensitive avian species (Blus 1995). For bald eagles (*Haliaeetus leucocephalus*) concentrations $\leq$3 ug/g ww in eggs appears to have no effects but almost complete nest failure occurred when eggs contained $\geq$16 ug/g ww (16,000 ng/g; Wiemeyer et al. 1984). DDE concentrations measured in mourning doves eggs from the Colorado River delta in Mexico, ranged from 4.3 ng/g ww to 58.6 ng/g ww, which were below the calculated NOAEL of 2.2 ug/g ww (2,200 ng/g ww) for terrestrial birds (Clark et al. 1995; Garcia-Hernandez et al. 2006). The DDE concentrations in mountain plover eggs collected in 2006 for this study ranged from 5 ng/g ww to 5,400 ng/g ww for eggs from Montana, from 10 ng/g ww to 930 ng/g ww for eggs from Wyoming, and from 11.0 ng/g ww to 11,500 ng/g ww for eggs from Colorado (Appendix 12). Furthermore, two eggs from Montana had DDE concentrations (3,000 ng/g ww and 5,400 ng/g ww) that were at least as high as those found to adversely affect productivity in pelicans. Two eggs from Colorado were near this concentration (2,700 ng/g ww and 2,900 ng/g ww) with an additional egg having a concentration (11,500 ng/g ww) approaching that known to affect bald eagle reproduction (Blus 1995).

Information on eggshell thickness of mountain plover eggs is lacking but the concentration of DDE associated with significant eggshell thinning (e.g. >20% thinner compared with pre-DDT eggshell thicknesses) ranged from 0.1 ug/g ww for the brown pelican (Blus 1984) to 2 ug/g ww for the peregrine falcon (Blus 1996). Concentrations of DDE in individual mountain plover eggs collected in Montana equaled or exceeded the threshold for significant thinning in brown pelicans in four of the seven eggs (range 0.1 – 5.4 ug/g ww) and DDE concentrations (3 ug/g ww and 5.4 ug/g ww) in two of these eggs exceeded the threshold for the peregrine falcon (Appendix 12). In Wyoming, DDE concentrations (0.9 ug/g ww and 0.93 ug/g/ww) in two of the seven eggs exceeded the threshold for significant thinning for brown pelicans but none exceeded the threshold for the peregrine falcon. Three of the five eggs collected from Colorado had DDE concentrations (range = 2.7 – 11.5 ug/g ww) that exceeded the threshold for significant thinning in sensitive species with one of these eggs (11.5 ug/g ww) exceeding the threshold for peregrine falcon.

Shell thickness of mountain plover eggs has not been reported prior to this report (Knopf and Wunder 2006; Appendices 13 – 15). Although our sample size is small and we did not attempt to located archived mountain plover eggshells, correlations between DDE concentrations and eggshell thickness were still investigated. According to Blus (1984), egg residues are more accurate for indicating nest success rather than eggshell thickness and because the amount of eggshell thinning resulting from each incremental increase in DDE concentration is greater at lower residue levels (USDOI 1998). Additionally, researchers have shown that eggshell thinning of 5 – 7% is statistically significant but that it probably is not biologically significant. Specifically, field studies have shown that an average thinning of 10% is seldom associated with egg breakage or population decline (USDOI 1998). As an example, 1 ug DDE/g may result in 5-10% thinning, whereas 59 ug/g can result in 44% thinning in brown pelicans (USDOI 1998).

Data on the eggs collected in 2006 and 2007 were used to determine if a correlation existed between eggshell thickness using the Ratcliffe Index (Ratcliffe 1970) and p’p’-DDE concentrations. Statistical analysis revealed a weak negative association between DDE residue and egg index thickness (Spearman r = -0.27), however the two variables were not statistically correlated (p = 0.185; Figure 21).

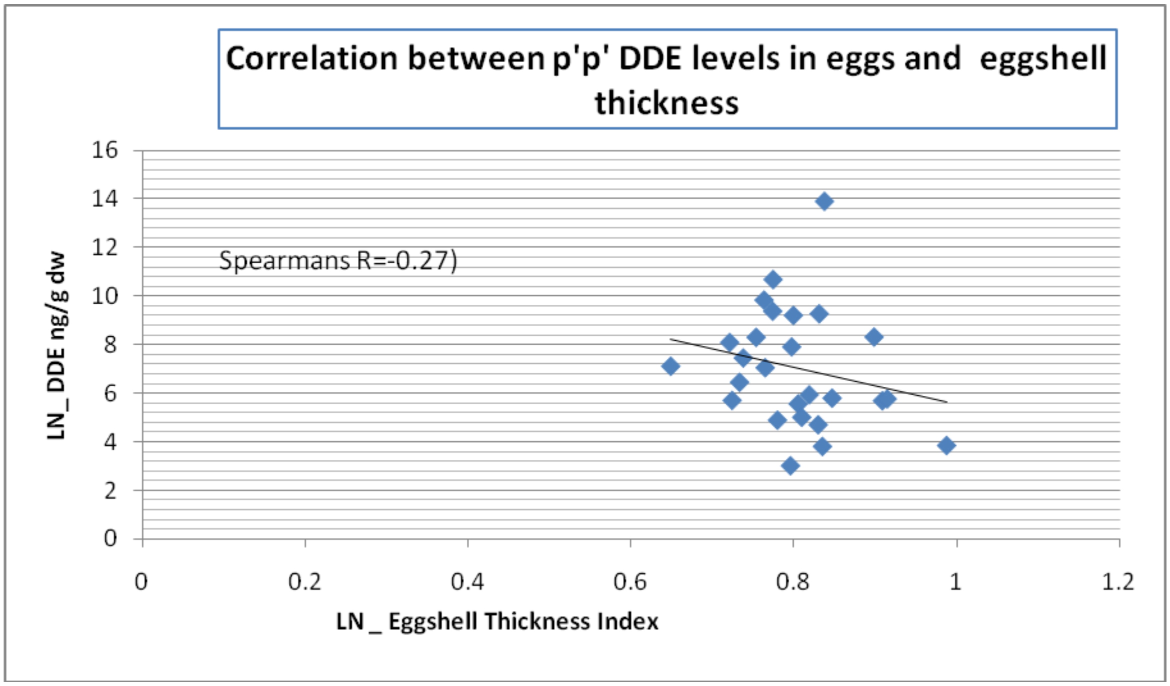

Figure 21. Correlation between p'p' DDE concentrations in eggs and eggshell thickness

Mountain Plover Eggs-Organic Compounds-2007

Eggs collected from sites in Wyoming and Colorado in 2007 did not have detectable levels of trifluralin or its metabolites. Trifluralin is one of the more heavily used pesticides on forage grass fields in Imperial County, California, and was present in invertebrate samples at concentrations that were many times higher than concentrations in soil. The absence of trifluralin in plover eggs could be for a variety of factors: plovers are not ingesting trifluralin-contaminated prey; plovers are exposed but the trifluralin is not accumulated in plover tissues; plovers ingest trifluralin but it is not transferred to the eggs; or plover ingest trifluralin but depurate any residues before arriving on breeding grounds.

Furthermore, only a few of the target organic analytes were detected in mountain plover eggs from breeding sites in Colorado and Wyoming (Table 11; Appendix 16 – 19). With the exception of DDT (primarily p,p'-DDE, but including DDDs and DDTs), PCBs, and oxychlordane, the organochlorine compounds were detected infrequently and generally at low

Table 11. Concentrations of detected organochlorine pesticides and total PCBs (**ng/g wet weight**) in egg samples collected from mountain plover breeding sites in Colorado and Wyoming, 2007.

Location	**Sample**	**% lipid**	**alpha BHC**	**1,2,3,4-Tetrachlorobenzene**	**dieldrin**	**HCB**	**trans-nonachlor**	**heptachlor epoxide**	**oxychlordane**	**o,p'-DDT**	**p,p'-DDE**	**PCB-TOTAL**
Pawnee National Grasslands, CO	MPWCPE06	0.83	<0.435	<0.435	3.37	<0.435	<0.435	0.97	1.27	1.68	51,200	33.6
Pawnee National Grasslands, CO	MPWCPE07	7.8	0.566	<0.424	<0.424	<0.424	<0.424	1.02	2.72	<0.42	783	13.8
Pawnee National Grasslands, CO	MPWCPE08	0.82	1.04	4.07	<0.446	<0.446	0.659	0.85	0.633	<0.	60.2	29.1
Pawnee National Grasslands, CO	MPWCPE09	1.20	0.697	<0.49	<0.49	<0.49	<0.49	<0.49	0.834	<0.49	213	13.3
Pawnee National Grasslands, CO	MPWCPE10	0.95	<0.459	<0.459	<0.459	<0.459	<0.459	<0.46	3.0	<0.459	35	9.17
Foote Creek Rim, WY	MPFCPE06	8.97	<0.495	<0.495	<0.495	1.77	<0.495	<0.495	2.63	<0.495	74.6	39.6

concentrations. Alpha-BHC, also known as hexachlorocyclohexane (HCH) was detected in three eggs from Colorado (1.97, 13.2, and 21.2 ng/g dw), at concentrations that were not much greater than the respective detection limits for the samples. That BHC was detected, albeit at low concentrations attests to the persistence of this substance, which has not been used in the U.S. since 1978 (Blus 1995; Wiemeyer 1996). The 1,2,3,4 isomer of tetrachlorobenzene was detected in one egg from Colorado but at a very low concentration (83.1 ng/g dw). This isomer is currently used in dielectric mixtures and is also a metabolite of γ HCH (lindane; Blus 1995; Handel et al. 2006).

Dieldrin was detected in one egg from Colorado at a concentration of 70.4 ng/g dw (3.37 ug/g ww). There are few data on what levels of dieldrin in eggs cause adverse effects. Brown pelicans, considered a sensitive species to OCs, had lower productivity when dieldrin concentrations in eggs were $\geq$1 ug/g ww ($\geq$1,000 ng/g ww; Blus 1995), although this effect has not been definitely established (Peakall 1996). In addition, researchers recommend caution with the interpretation of effects of individual OCs because many OC compounds occur with other OCs, and effects, which are compound specific (e.g., lethality caused by dieldrin, or eggshell thinning caused by DDE) may or may not be additive (Blus 1995). This may be the case with this particular egg because other OCs (heptachlor epoxide, o,p'-DDT, p,p'-DDE, and oxychlordane) were detected along with the dieldrin.

Hexachlorobenzene was detected at a concentration of 9.24 ug/g dw (1.77 ug/g ww) in the single egg collected from FCR, Wyoming. The detection does not appear to be an anomaly as HCB was detected at roughly similar concentrations (max = 8.4 ug/g dw) in multiple eggs collected from the same site in 2006 (Table 10). Unfortunately, data relating adverse effects to HCB levels in terrestrial birds are lacking. The lipid weight-based concentration detected in in the plover egg from Colorado (~20 ng/g lipid) would be considered low, based on other studies of OCs in terrestrial species (Jaspers et al. 2005). The detected concentration is also orders of magnitude below levels identified as NOAEL for reproductive effects in seabirds (Boersma et al. 1986) and waterfowl (Blus et al. 1984).

Trans-nonachlor, heptachlor epoxide, and oxychlordane detected in mountain plover eggs are all constituents of technical chlordane, with heptachlor epoxide and oxychlordane being the more toxic products (Wiemeyer 1996). Trans-nonachlor is deemed relatively non-toxic to birds but it is possible it is metabolized to oxychlordane (Stickel et al. 1983). While there have been a few studies on levels in the diet that are toxic, data relating chlordane concentrations, or its metabolite oxychlordane, in eggs to reproductive effects are lacking (Wiemeyer 1996). Concentrations of heptachlor epoxide detected in plover eggs are orders of magnitude lower than concentrations that appear to be associated with adverse effects in American kestrels (*Falco sparverius*; >1,500 ng/g), Japanese quail (>10,000 ng/g), and gray partridge (*Perdix perdix*; ~3,000 – 7,000 ng/g ww; Wiemeyer 1996).

As in 2006, all eggs collected in 2007 had detectable levels of p,p'-DDE (range = 35 – 51,200 ng/g ww; Table 11). The highest concentration of DDE was from an egg collected in Colorado. The DDE residue was 51,200 ng/g ww (51.2 ug/g ww), which is well above the 3 ug/g shown to cause almost colony failure in brown pelicans (Blus 1995) and above the 16 ug/g ww level shown to cause complete nest failure in eggs of bald eagles (Wiemeyer et al. 1984). This egg also had detectable concentrations of o,p'-DDT (1.68 ng/g ww), dieldrin, heptachlor epoxide, oxychlordane, and PCBs, which, if acting additively, increases the potential for adverse effects (Wiemeyer 1996; USDOI 1998).

PCBs were the second most prevalent OC detected in mountain plover eggs, with concentrations ranging from 9.2 – 42 ng/g ww. PCBs were used primarily in electrical transformers and capacitors for their insulating and cooling properties. The manufacturing of PCBs was banned in the U.S. by 1977. Because of their persistence, PCBs are found worldwide (Rice and O'Keefe 1995), so it is not surprising that mountain plover eggs contained detectable total PCBs. PCBs are known to affect survival and reproductive success in birds but at levels much higher than those detected in this study with mountain plovers (Hoffman et al. 1996).

Mountain Plover Eggs-Organic Compounds-2008

In 2008, eggs were collected from BLM lands, Phillips County, Montana. Like eggs collected from Colorado and Wyoming in 2007, these had no detectable levels of trifluralin or its metabolites, confirming the previous observation that either the plovers are not ingesting trifluralin-contaminated prey, or more probably, that they are experiencing dietary exposure, but the trifluralin is not accumulated by the mountain plovers and subsequently transferred to the eggs. Unlike the eggs collected from Colorado and Wyoming in 2007, most of the target OC compounds were detected in one or more of the eggs collected from Montana in 2008. Of the detected analytes, only nine were detected frequently (i.e., in >four out of eight samples) and three (p'p-DDE, HCB, and PCBs) were detected in nearly all, if not all, of the eggs that were collected (Table 12; Appendices 20 – 23).

Table 12. Concentration of detected organic analytes (ng/g dw) in mountain plover eggs collected from BLM lands, Montana in 2008.

Analyte	**minimum**	**maximum**	**Detects (out of 8)**
alpha BHC	<1.60	4.22	5
alpha chlordane	<1.60	1.79	1
beta BHC	<1.60	1.43	2
chlorpyrifos	<1.60	12.8	4
dieldrin	<1.60	130	4
endosulfan II	<1.60	6.18	1
endrin	<1.60	139	4
gamma chlordane	<1.60	2.5	1
HCB	4.43	32.4	8
heptachlor	<1.60	2.63	1
heptachlor epoxide	<1.60	15.4	2
mirex	<1.60	12.6	3
o,p'-DDD	<1.60	2.44	1
o,p'-DDE	<1.60	33.2	1
o,p'-DDT	<1.60	6.67	1
oxychlordane	<1.60	111	5
p,p'-DDD	<1.60	320	3
p,p'-DDE	16.4	185,000	7
p,p'-DDT	<1.60	57.6	3
pentachloro-anisole	<1.60	3.54	4
1,2,3,4-Tetrachloro-benzene	<1.60	9.38	4
1,2,4,5-Tetrachloro-benzene	<1.60	20.4	3
trans-nonachlor	<1.60	2.99	1
PCB TOTAL	75.9	2,760	8

Alpha BHC, alpha chlordane, beta-BHC, endosulfan II, gamma chlordane, heptachlor, pentachloro-anisole, and trans-nonachlor were detected in one or more mountain plover eggs collected from Montana but at low concentrations (Blus 1995; Wiemeyer 1996; Appendix 20). Mirex was found in three eggs at concentrations not likely to affect embryo survival (Wiemeyer 1996). Although mirex was banned in 1978, it is considered extremely persistent (Eisler 1985b) and one of its breakdown products is HCB, which was detected in all of the eggs. The HCB was detected at low concentrations (Table 12), but its presence reflects its persistence in the environment as it has not been used in the U.S. since 1978 (Blus 1995; Wiemeyer 1996). The maximum HCB concentration observed in the eggs from Montana (32.4 ug/g dw) is comparable to the highest level (32.5 ng/g dw) detected in eggs from PNG in 2006 (Table 10; Appendix 12). Although, female birds pass HCB directly into the egg (primarily the yolk), little information exists on the effects of these concentrations on embryo survival and health (Ingebrigsten et al. 1981; Breslin et al. 1983). One study on Japanese quail indicated that levels of 80 ug/g ww (8,000 ng/g) or higher were necessary before reproductive failure occurred (as cited in Bechard 1981). It is unlikely that the concentrations of HCB found in these eggs would adversely affect the mountain plover embryos.

Heptachlor, which was used primarily to control soil insect pests, was detected in only one plover egg at a low concentration (Table 12). Heptachlor, if ingested by vertebrate animals, is readily metabolized to heptachlor epoxide and like other OCs can be passed from the female bird to the egg (Henny et al. 1983; Henny et al. 1984). Heptachlor epoxide as well as trans-nonachlor and oxychlordane were contained in the insecticide chlordane but neither heptachlor nor chlordane is used in the U.S. anymore (Wiemeyer 1996). These other chlordane-related compounds were detected infrequently and at low concentrations in eggs collected from Montana. Trans-nonachlor was found in one plover egg at a low concentration (2.99 ng/g dw). This same egg also contained heptachlor epoxide and oxychlordane at low concentrations (9.84 ng/g dw and 18.7 ng/g dw, respectively). An additional egg also contained these latter two OCs at low concentrations (15.4 ng/g dw and 10.1 ng/g dw, respectively) but not trans-nonachlor. One egg contained a high concentration of oxychlordane (111 ng/g dw) but did not have any trans-nonachlor or heptachlor epoxide residues. Both heptachlor epoxide and oxychlordane are considered toxic to birds; whereas, trans-nonachlor is considered relatively non-toxic to birds. It is possible, however, for trans-nonachlor to be metabolized to oxychlordane explaining the absence of the specific metabolite in the third egg (Stickel et al. 1983).

Dieldrin and endrin were detected in one egg at low concentrations (5.33 ng/g dw and 1.84 ng/g dw, respectively) but two other eggs had much higher concentrations of both these compounds (egg # S10P001E1 had a dieldrin and endrin residue of 130 ng/g dw and 88.5 ng/g dw, respectively; egg #S10P001E2 had a dieldrin and endrin residue of 125 ng/g dw and 139 ng/g dw, respectively). Both dieldrin and endrin are cyclodiene pesticides. Dieldrin is very persistent while endrin is less so but endrin is considered highly toxic (Peakall 1996). Blus (1995) and Peakall (1996) identified a concentration of 0.5 ug/g as the critical level for endrin in brown pelican eggs, with higher levels leading to possible impairment. In owls, reproductive impairment occurred when endrin residues in eggs were 0.27 ug/g ww (Fleming et al. 1982; Peakall 1996). The individual concentrations of dieldrin and endrin are below critical levels for pelicans and owls. But when individual OCs co-occur with other OCs there is the potential for additive effects (Blus 1995). Both of these eggs contain residues of other OCs (e.g. DDE, oxychlordane) that may increase the odds that the embryos may have been adversely affected.

DDT or one of its metabolites was detected in seven of the eight mountain plover eggs, although only p, p’-DDD, p,p’-DDE, p,p’-DDT have been shown to cause adverse effects (Blus 1996). DDT and its metabolites are the dominant class of organochlorine contaminants in plover eggs, with concentrations that are orders of magnitude greater than concentrations of the other OCs. Although at low concentrations compared with metabolites (especially DDE), DDT was detected in some eggs, even though the use of the parent compound in the U.S. was banned in 1972. The source of the DDT may be residual from past uses or it may have been transported into U.S. via wind from parts of the world where DDT is still in use (USDOI 1998). DDT was detected in most soil samples and some invertebrate samples from wintering areas in Imperial Valley. Given the proximity to Mexico, where DDT is still in use, the source of the DDT in Imperial Valley soils and invertebrates, may well be drift from Mexico. In addition, the three mountain plover eggs with detectable levels of p,p’-DDT may have overwintered in Mexico. DDD was also detected in three eggs but concentrations were not elevated and it is not associated with significant eggshell thinning like DDE (USDOI 1998). DDE concentrations in two eggs (47.5

ug/g ww and 53.2 ug/g ww) were very high and above the 3 ug/g shown to cause almost complete colony failure due to egg breakage in brown pelicans (Blus 1995). These two eggs also had concentrations greater than 16 ug/g ww, which has been found to cause complete failure in eggs of bald eagles (Wiemeyer et al. 1984). It is very possible these two eggs were not viable because of these DDE concentrations and the likelihood of either additive or synergistic effects from the other detected OC residues (Wiemeyer 1996, USDOI 1998).

Four eggs had detectable concentrations of 1,2,3,4-tetrachlorobenzene (range 6.17 – 9.38 ng/g dw) and two eggs had detectable levels of 1,2,4,5-tetrachlorobenzene (19.0 ng/g dw and 20.4 ng/g dw; Appendix 20). These compounds may be present in the system as metabolites of the pesticide lindane (Menzie 1980). They were also used in DDT mixtures and dielectric fluids (Blus 1995; Handel et al. 2006). The concentrations observed in plover eggs are considered low (Blus 1995).

Total PCBs were detected in all eggs (75.9 – 2,760 ng/g dw; Appendix 20) at concentrations second only to DDT and its metabolites. Although banned in 1997, PCBs are found worldwide (Rice and O'Keefe 1995). Concentrations of PCBs measured in mountain plover eggs were lower than what is known to affect survival and reproductive success in other birds (Hoffman et al. 1996).

Chlorpyrifos was detected at concentrations between 3.01 ng/g dw and 12.8 ng/g dw in four of the eight eggs collected from Montana. Chlorpyrifos is a broad spectrum OP insecticide and although it is no longer used to kill mosquitoes, it is still registered for terrestrial systems (PMEP 2011). Unlike OCs, OPs are typically short-lived in the environment. The primary route of toxicity is through dietary ingestion or dermal application (Odenkirchen and Eisler 1988). These pesticides are also metabolized or excreted rapidly by most animals and do not bioaccumulate or biomagnify through the food chain (Hill 1995). OPs are not transferred from a mother bird to an egg in amounts that are biologically important (Hill 1995), although a mother can transfer the pesticide via her feathers while incubating the eggs or the egg can become contaminated from direct pesticide application (Hill 1995). No known chlorpyrifos applications occurred in the

Montana study area and it was not detected in soil or terrestrial invertebrate samples. Therefore, it is unknown as to why this insecticide was found in the mountain plover eggs.

Mountain Plover Eggs-Organic Compounds-2003

All of the eggs collected in 2003 had detectable levels of alpha-BHC, alpha-chlordane, cis-nonachlor, HCB, pentachloroanisole, trans-nonachlor, but at concentrations that are considered low (Appendices 24 – 26; Blus 1995; Wiemeyer 1996). Beta-BHC was also detected in eggs collected in 2003, with one egg from Shirley Basin, Wyoming, exhibiting a concentration (77.5 ng/g dw) that was notably higher than the other eggs. Little if anything is known about the toxicity of beta-BHC, which is the main BHC isomer retained and accumulated in animal tissues. In general, BHC is considered not very toxic to avian embryos (Wiemeyer 1996). There are limited data on γ-BHC (lindane), which is the most active as an insecticide of the BHC isomers. In two studies, no effects were observed even when concentrations of γ-BHC in eggs were as high as 10,000 ng/g for ring-necked pheasant (Blus et al. 1984) and 5,500 ng/g for American kestrel (review by Wiemeyer 1996). Beta-BHC concentrations observed in mountain plover eggs (maximum 77.5 ng/g dw) are orders of magnitude lower than no effect levels for gamma-BHC in other species and therefore are of minor concern at this time (IPCS 2010).

Dieldrin and endrin concentrations observed in mountain plover eggs were below levels of concern based on studies with brown pelicans and owls (Fleming et al. 1982; Blus 1995; Peakall 1996). However, because other OCs are present (e.g. p,p'-DDE) and the toxicity of individual OCs may be additive, there is the potential for negative effects of combined OCs on mountain plover embryos, particularly in the one egg (sample # MPSBPE04) collected from Shirley Basin, which has a very high DDE residue (Blus 1995).

Heptachlor epoxide and oxychlordane are metabolites of chlordane and heptachlor epoxide is also a metabolite of heptachlor. Most of the toxicity data on these compounds is for heptachlor epoxide for which concentrations in eggs associated with adverse effects appear to be >1,500 ng/g in American kestrels, >10,000 ng/g Japanese quail, and 3,000 – 7,000 ng/g in gray partridge (Wiemeyer 1996). Concentrations of heptachlor epoxide and oxychlordane in eggs were all below 30 ng/g dw and are orders of magnitude lower than thresholds for other species. While concentrations of heptachlor epoxide and oxychlordane are below levels of concern individually, there is still concern about the potential for these substances to add to the toxicity of other OCs that are present, most notably DDE (Blus 1995; Wiemeyer 1996).

Both 1,2,3,4- and 1,2,4,5-tetrachorobenzenewere detected in eggs from Park County but not from Albany County or Shirley Basin. These products are metabolites of the insecticide lindane. Overall, concentrations were low (Appendix 25), but one egg (sample # MPCDPE05) from Park County had higher concentrations than any of the other eggs (40.8 ng/g dw and 61.6 ng/g dw, respectively). This egg also had a DDE concentration of 6,000 ng/g ww, which is above the concentration known to cause colony failure in brown pelicans (Blus 1995). It is unknown if levels of 1,2,3,4- and 1,2,4,5-tetrachlorobenzene measured in egg #MPCDPE05 are at concentrations to affect survival of mountain plover embryos. However, as stated above, these OCs may act additively with other OCs that are present (Blus 1995).

DDT was detected in three eggs (all <4.0 ng/g dw), and DDD was detected in one egg (31.6 ug/g dw) at concentrations that are considered to be low (Blus 1996; USDOI 1998). DDE was detected in all eggs with concentrations ranging from 192 ng/g dw to 292,000 ng/g dw (Appendix 25). The egg with the highest concentration (192,000 ng/g dw or 80,000 ng/g ww) is the same egg (sample # MPSBPE04) from Shirley Basin in which many other OCs were detected and could contribute additive toxicity to the embryo (Blus 1995). At 80,000 ng/g ww (80 ug/g ww), this DDE level is significantly greater than the 3 ug/g shown to cause almost complete colony failure due to egg breakage in brown pelicans (Blus 1995) and above the 16 ug/g ww found to cause complete failure in bald eagle eggs (Wiemeyer et al. 1984). It is unknown if this egg was viable when it was collected but because of the DDE concentration it is very likely that the egg would not have hatched (Wiemeyer 1996, USDOI 1998).

As with eggs collected in 2006 – 2008, PCBs were detected in all eggs except two eggs from Shirley Basin (Appendix 25). PCBs were the second most abundant of the OCs, after DDE, with detected concentrations that ranged from approximately 40 ng/g dw to 400 ng/g dw. Even so, concentrations were lower than what is known to affect survival and reproductive success in other birds (Hoffman et al. 1996).

CONCLUSIONS

Mountain plover on their wintering grounds in California are exposed to elevated levels of trace elements and organic contaminants. The only contaminants from the wintering grounds that appear in eggs at levels of concern are OCs. Organic contaminants were below the limits of detection in soil and invertebrate samples collected on the plovers' breeding grounds, so detection of the OC in eggs is likely linked to exposures that occur to adults on their wintering grounds in California, Arizona, Texas, and Mexico. This study only has data on wintering grounds in California, but nearly half of the United States population of mountain plover winter in the state (USFWS 2011)

DDT and its metabolites are still present in agricultural fields in the Imperial and Central Valleys of California (USDOI 1998; Kegley et al. 1999; Gervais et al. 2000), although DDT was banned in 1972. One of the most significant findings of this study was the high DDE levels found in soils and invertebrates collected in the Imperial Valley, and in eggs collected in Colorado, Montana, and Wyoming. Similar results were found in studies investigating burrowing owls using the Central and Imperial Valleys in California. Residues of p,p'- DDE in burrowing owl eggs in the Imperial Valley were documented in 1996 and 2002, and during the six years between collections, p,p'- DDE did not decline. In addition, eggshells measured in 1996 were 22% thinner than eggs collected prior to 1937 (Gervais et al. 2000; Gervais and Catlin 2004). Previous research also found mountain plover eggs contained a range of p,p'-DDE from 0.05 to 17 ug/g ww (Archuleta, USFWS, unpubl. data). Additionally, p,p'-DDT was detected in seven out of 25 adult mountain plover carcasses at concentrations from 0.02 ug/g dw to 0.36 ug/g dw (Archuleta, USFWS, unpubl.data), indicating exposure to parent product is still occurring. Table 13 compares concentration of DDE collected in this study to p,p'-DDE levels found in burrowing owl studies mentioned previously (Gervais et al. 2000; Gervais and Catlin 2004).

Mountain plover egg residues of p,p'-DDE levels were also compared to literature effects levels. Many eggs were well below any effects levels but several eggs exceeded the effects levels (Gervais et al. 2000; Figure 22). Understanding where breeding adults spent their winters may

Table 13. Concentrations of DDE in mountain plover eggs collected in Colorado, Montana, and Wyoming, compared to burrowing owl eggs collected in the Central and Imperial Valleys of California.

Location	**Species of Bird Egg collected and number (n)**	**Mean p,p'-DDE ug/g (ww)**
Pawnee National Grasslands, CO (2006)	Mountain Plover (5)	3.44
BLM Lands and CMR, Phillips County, MT (2006)	Mountain Plover (8)	1.32
Near Antelope Coal Mine and Foote Creek Rim, WY (2006)	Mountain Plover (7)	0.324
SBSS NWR (1996)	Burrowing Owl (5)	1.19
Near Pixley NWR (1996)	Burrowing Owl (7)	0.62

help with future management actions. Adults spending winters in Mexico may be exposed to much higher levels of p,p'-DDE than those wintering in California.

Trifluralin was not detected in eggs collected in this investigation, although exposures likely occur to plovers through soil ingestion and invertebrate food items on wintering grounds. The RED on trifluralin identified cracked eggshells as a common endpoint in northern bobwhite quail and mallard duck exposed to the herbicide (USEPA 1996). All mountain plover eggs collected in Montana in 2008 had cracked shells. The studies cited in the RED did not report concentrations in eggs (USEPA 1996) and did not go into the reasons for decreased eggshell integrity. Because mountain plovers are exposed to trifluralin in addition to p,p'-DDE levels, they may be at increased risk of compromised eggshells from both of these contaminants.

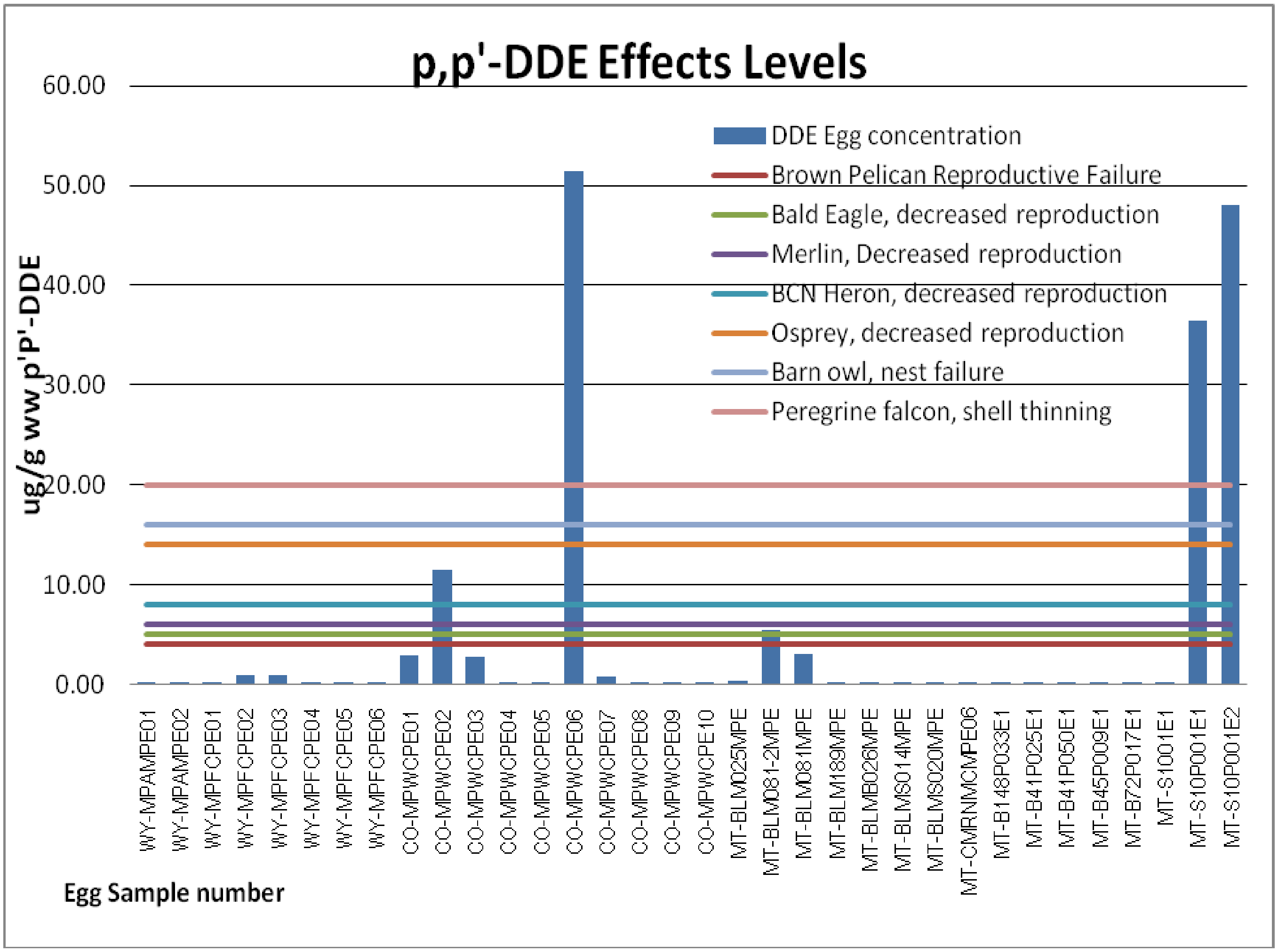

Figure 22. Mountain plover egg data compared to p,p'-DDE effects levels

MANAGEMENT RECOMMENDATIONS

Mountain plovers winter in the Central and Imperial Valleys of California, Arizona, Texas, and Mexico. In fact, approximately half of the entire United States population winters in California (USFWS 2011), with the Imperial Valley becoming the increasingly favored location. Both the Central and Imperial Valleys report year round agriculture with over 809,400 ha (2 million acres) in production. While wintering in the Imperial Valley, mountain plovers spend the early winter in harvested or fallow alfalfa fields before switching over to Bermuda grass fields after the fields are burned in late winter (F. Knopf, pers. comm. 2/05). Because of the documented potential exposures to mountain plovers on their wintering grounds, any actions to create suitable habitat with lower contaminant concentrations on refuge grounds would be beneficial.

Although the Kern NWR is located within an intensive agricultural area, studies in 1986-1987 found that pesticide residues and trace element concentrations were comparatively low (USFWS 2000). The low concentrations measured at the Kern NWR suggest these contaminants pose little threat to wildlife; however, impounded subsurface drainage and evaporation ponds from agricultural irrigation do pose a potential threat to wildlife (USFWS 2000). Results of samples collected in 2006 also revealed the lowest levels of contaminants of any of the study sites on the wintering grounds. In the 1960's mountain plover numbers on Kern NWR ranged from 1,000 to 10,000, but no sightings have been recorded since 1985 (USFWS 2005). Similarly, another nearby refuge, Pixley NWR, not sampled in this investigation because of the presence of the endangered blunt-nosed leopard lizard, has also experienced declining plover numbers. In 1993, 109 plovers were documented, decreasing to 21 in 1994, and 15 in 1997 when the last sighting was made (USFWS 2005). As with Kern NWR, Pixley NWR is located in a highly agricultural area but studies in 1986-1987 found that pesticide residues and trace element levels were low (USFWS 1999b). Attempts to provide habitats on Kern and Pixley NWRs to attract mountain plovers could potentially reduce contaminant exposures.

In the Imperial Valley, SBSSNWR had lower contaminant concentrations than other samples collected, but still higher than samples collected on Kern NWR. Plover use on the refuge is minimal but could perhaps be managed to increase plover use in this specific area. The Refuge has approximately 352 ha (869 acres) of croplands with many fields cooperatively farmed by local farmers. Giving preference to those farmers that plant and mange fields that attract plovers may help lower exposure to the more contaminated Imperial Valley fields.

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Appendices

Appendix 1. Concentrations of inorganics* (ug/g dry weight) in soil samples collected from mountain plover wintering sites in California, 2006.

Location	Sample	Al ug/g dw	As ug/g dw	B ug/g dw	Ba ug/g dw	Be ug/g dw	Ca ug/g dw	Cd ug/g dw	Co ug/g dw	Cr ug/g dw	Cu ug/g dw
Imperial Valley J20	S-IV-J20A	21400	7.05	9.28	309	1.12	81300	1.48	8	27.7	29.5
Imperial Valley J20	S-IV-J20B	17100	6.25	5.48	311	1.06	80200	2.54	7.3	33.4	30.8
Imperial Valley J20	S-IV-J20C	20000	7.05	7.24	307	1.09	84800	1.54	7.79	28.5	30.8
Imperial Valley J20	S-IV-J20D	17500	6.07	4.71	315	1.1	82100	2.13	7.58	32.3	32.8
Imperial Valley J20	S-IV-J20E	23500	6.39	10.4	324	1.2	78600	1.94	8.41	32.5	32.1
Imperial Valley J22	S-IV-J22A	20000	6.05	9.07	314	1.24	77000	3.26	7.4	53	31.3
Imperial Valley J22	S-IV-J22B	19700	5.93	11.2	321	1.11	80300	2.56	7.6	31.3	34.1
Imperial Valley J22	S-IV-J22C	19800	5.74	10.4	314	1.05	85700	1.87	8.04	27.5	38.7
Imperial Valley J22	S-IV-J22D	19000	5.95	9.04	326	1.17	92800	4.66	7.49	49.2	35.8
Imperial Valley J22	S-IV-J22E	17900	5.85	7.73	309	1.14	81600	4.16	7.17	45.7	28.5
Imperial Valley K18	S-IV-K18A	19700	5	5.81	266	1.19	69000	2.36	7.61	36.1	24.6
Imperial Valley K18	S-IV-K18B	22800	5.56	6.22	292	1.23	72400	2.34	8.43	33.3	28.8
Imperial Valley K18	S-IV-K18C	24900	6.25	8.92	291	1.26	75800	1.91	8.5	30.9	28.7
Imperial Valley K18	S-IV-K18D	24600	6	6.44	296	1.28	78900	2.88	8.45	37.1	29.7
Imperial Valley K18	S-IV-K18E	23900	5.81	6.7	313	1.3	91600	3.78	8.23	42	34.3
Sonny Bono NWR	S-SB-420A	22800	7.08	6.37	234	1.17	51000	0.388	9.27	22.1	25.7
Sonny Bono NWR	S-SB-420B	22900	8.25	6.91	239	1.18	50000	0.435	9.35	21.7	26.4
Sonny Bono NWR	S-SB-420C	22500	6.57	6.27	242	1.17	50700	0.37	9.34	21.5	25.3
Sonny Bono NWR	S-SB-420D	24900	7.38	5.21	239	1.29	50500	0.373	10.2	23.2	29.6
Sonny Bono NWR	S-SB-420E	29000	7.39	9.95	249	1.41	50600	0.378	10.5	25.6	29.1
Kern NWR	S-K-15A	12800	3.3	35.8	152	0.363	36000	0.371	4.07	22	10.6
Kern NWR	S-K-15B	23600	4.23	72	131	0.684	45300	0.543	8.61	31.8	25.1
Kern NWR	S-K-15C	13100	2.03	42.7	110	0.373	33800	0.349	3.85	22	11.2
Kern NWR	S-K-15D	18400	2.93	55.6	112	0.52	37600	0.405	5.8	26.1	28.4
Kern NWR	S-K-15E	18000	2.12	34.3	123	0.49	29600	0.354	5.89	28.5	12.1

Appendix 1. cont.

Location	Sample	Hg ug/g dw	K ug/g dw	Mg ug/g dw	Mn ug/g dw	Mo ug/g dw	Na ug/g dw	Ni ug/g dw	P ug/g dw	Pb ug/g dw	S ug/g dw
Imperial Valley J20	S-IV-J20A	0.0153	4810	14700	461	1.18	2640	18.4	1370	14.9	1610
Imperial Valley J20	S-IV-J20B	0.0155	3880	13200	483	<1.02	847	17.7	2200	13.4	1560
Imperial Valley J20	S-IV-J20C	0.0153	4480	14500	471	<1.01	937	18.1	1760	13.8	1190
Imperial Valley J20	S-IV-J20D	0.0156	3900	13900	503	1.22	883	18.5	2260	13.8	1500
Imperial Valley J20	S-IV-J20E	0.0162	5050	14900	506	1.11	804	19.8	1770	14.3	1240
Imperial Valley J22	S-IV-J22A	0.0182	4700	13300	489	1.39	995	20.2	2810	14.2	2080
Imperial Valley J22	S-IV-J22B	0.0185	5240	15000	482	1.07	1460	18.6	3440	13.4	2050
Imperial Valley J22	S-IV-J22C	0.0171	5250	14900	487	<1.01	1310	18.5	3040	13.9	1920
Imperial Valley J22	S-IV-J22D	0.0168	4770	14100	548	1.22	1370	21.3	3650	14.9	2330
Imperial Valley J22	S-IV-J22E	0.0182	4100	12900	494	1.06	1240	19	2740	14.2	2090
Imperial Valley K18	S-IV-K18A	0.0161	4050	12700	436	<1.02	827	19	2390	14.4	1180
Imperial Valley K18	S-IV-K18B	0.0156	4970	14300	460	<1.01	1140	20.1	2370	15.8	1300
Imperial Valley K18	S-IV-K18C	0.0152	5170	14700	449	<1.02	1130	20.1	1840	17.6	1160
Imperial Valley K18	S-IV-K18D	0.0162	5010	14400	476	<1.01	887	19.9	2780	16.7	1080
Imperial Valley K18	S-IV-K18E	0.0169	4860	14400	478	<1.01	804	20	3060	16.5	1200
Sonny Bono NWR	S-SB-420A	0.0181	4920	14400	479	1.26	1190	21.5	781	18.3	646
Sonny Bono NWR	S-SB-420B	0.0175	4890	14500	478	1.29	1400	21.5	801	21	798
Sonny Bono NWR	S-SB-420C	0.0189	4690	14400	483	1.1	1390	20.4	795	17.6	696
Sonny Bono NWR	S-SB-420D	0.0179	5550	15300	519	1.28	1700	22.6	822	18.5	1180
Sonny Bono NWR	S-SB-420E	0.018	5960	16000	534	1.18	1460	23.3	818	19.2	748
Kern NWR	S-K-15A	0.00985	4580	9600	341	<1.01	3180	17.4	2040	5.94	572
Kern NWR	S-K-15B	0.011	7620	18600	531	3.08	8950	28.7	2080	8.27	1340
Kern NWR	S-K-15C	0.0266	4670	10900	317	<1.01	4110	17.5	2120	4.94	574
Kern NWR	S-K-15D	0.0108	6000	13600	410	1.03	7690	22.4	1590	6.61	897
Kern NWR	S-K-15E	0.00939	5960	12200	392	1.07	3490	23.1	1410	6.84	387

Appendix 1. cont.

Location	Sample	Se ug/g dw	Sr ug/g dw	V ug/g dw	Zn ug/g dw
Imperial Valley J20	S-IV-J20A	0.56	392	37.5	1130
Imperial Valley J20	S-IV-J20B	0.76	413	31.3	3900
Imperial Valley J20	S-IV-J20C	0.59	417	35.6	2060
Imperial Valley J20	S-IV-J20D	0.74	418	31.7	3690
Imperial Valley J20	S-IV-J20E	0.73	393	38	2040
Imperial Valley J22	S-IV-J22A	1.11	399	36.2	9310
Imperial Valley J22	S-IV-J22B	0.88	443	36.7	4310
Imperial Valley J22	S-IV-J22C	0.72	454	36.1	1170
Imperial Valley J22	S-IV-J22D	1.03	504	36.1	6230
Imperial Valley J22	S-IV-J22E	0.84	405	35.1	7520
Imperial Valley K18	S-IV-K18A	0.72	338	37.9	2700
Imperial Valley K18	S-IV-K18B	0.56	361	40.2	1750
Imperial Valley K18	S-IV-K18C	0.55	375	42.5	392
Imperial Valley K18	S-IV-K18D	0.59	400	42.6	1030
Imperial Valley K18	S-IV-K18E	0.6	482	43.4	1290
Sonny Bono NWR	S-SB-420A	0.38	216	40.5	75.2
Sonny Bono NWR	S-SB-420B	0.37	218	40.1	78
Sonny Bono NWR	S-SB-420C	0.39	221	39.8	75.8
Sonny Bono NWR	S-SB-420D	0.41	233	42.6	80.4
Sonny Bono NWR	S-SB-420E	0.42	231	47.1	84.3
Kern NWR	S-K-15A	0.08	284	25.8	44.9
Kern NWR	S-K-15B	0.11	394	51	79.4
Kern NWR	S-K-15C	0.08	323	27.4	44.4
Kern NWR	S-K-15D	0.08	332	36.3	57.4
Kern NWR	S-K-15E	0.07	235	34.7	57.3

*Perchlorate and silver not detected in any soil samples.

Appendix 2. Concentrations of organic pesticides* and trifluralin (ng/g dry weight) in soil samples collected from mountain plover wintering sites in California, 2006.

Location	**Sample**	**1,2,3,4-tetra-chlorobenzene** ng/g dw	**1,2,4,5-tetra-chlorobenzene** ng/g dw	**aldrin** ng/g dw	**alpha BHC** ng/g dw	**alpha-chlordane** ng/g dw	**beta BHC** ng/g dw	**chlorpyrifos** ng/g dw	**cis-nonachlor** ng/g dw
Imperial Valley J20	S-IV-J20A	<0.0316	0.092	<0.0316	0.046	0.305	<0.0316	0.266	1.19
Imperial Valley J20	S-IV-J20B	0.0523	0.184	0.0591	0.0716	0.606	<0.0283	0.843	1.48
Imperial Valley J20	S-IV-J20C	<0.0278	0.264	0.0552	0.0744	0.856	<0.0278	0.91	2.18
Imperial Valley J20	S-IV-J20D	0.0343	1.31	0.072	0.0753	0.589	<0.0274	0.9	1.45
Imperial Valley J20	S-IV-J20E	<0.029	0.652	0.0762	0.0621	0.657	<0.029	1.07	1.32
Imperial Valley J22	S-IV-J22A	<0.0277	1.29	0.0839	0.047	0.977	<0.0277	0.464	0.853
Imperial Valley J22	S-IV-J22B	<0.0291	1.21	0.152	0.0436	1.59	<0.0291	0.931	1.7
Imperial Valley J22	S-IV-J22C	<0.0284	0.199	0.0928	0.0699	1.51	<0.0284	1.05	1.76
Imperial Valley J22	S-IV-J22D	<0.029	0.214	0.105	0.0536	0.585	<0.029	0.589	0.762
Imperial Valley J22	S-IV-J22E	<0.0276	0.0707	<0.0276	0.0354	0.235	<0.0276	0.503	0.343
Imperial Valley K18	S-IV-K18A	0.077	0.321	<0.0274	0.0517	0.0363	<0.0274	0.177	0.103
Imperial Valley K18	S-IV-K18B	<0.0275	0.313	0.0725	0.0457	<0.0275	<0.0275	0.284	0.105
Imperial Valley K18	S-IV-K18C	<0.028	0.48	0.0676	0.0394	0.036	<0.028	0.243	0.0822
Imperial Valley K18	S-IV-K18D	0.0898	0.602	0.0875	0.0505	0.0572	<0.028	0.325	0.0696
Imperial Valley K18	S-IV-K18E	<0.0286	0.341	0.145	0.0338	0.0502	<0.0286	0.293	0.0945
Sonny Bono NWR	S-SB-420A	<0.0256	0.346	<0.0256	0.178	0.0323	0.0428	0.489	0.165
Sonny Bono NWR	S-SB-420B	<0.0257	0.318	<0.0257	0.222	<0.0257	0.0433	0.651	0.161
Sonny Bono NWR	S-SB-420C	<0.0259	0.348	<0.0259	0.241	0.0272	0.0418	0.798	0.17
Sonny Bono NWR	S-SB-420D	<0.0259	0.218	<0.0259	0.215	0.0315	0.0462	0.609	0.185
Sonny Bono NWR	S-SB-420E	<0.026	0.455	<0.026	0.221	0.0419	0.0765	0.55	0.164
Kern NWR	S-K-15A	0.0369	0.175	<0.0252	0.0461	0.181	0.0338	0.11	0.0615
Kern NWR	S-K-15B	<0.0267	0.148	<0.0267	0.0334	0.121	<0.0267	0.0971	0.0852
Kern NWR	S-K-15C	<0.0261	0.139	<0.0261	0.0295	0.145	<0.0261	0.0411	0.0538
Kern NWR	S-K-15D	<0.0261	0.147	<0.0261	<0.0261	0.0794	0.0307	<0.0261	0.0529
Kern NWR	S-K-15E	<0.0261	0.13	<0.0261	0.0263	0.0727	<0.0261	0.0306	<0.0261

Appendix 2. cont.

Location	Sample	delta BHC ng/g dw	dieldrin ng/g dw	endosulfan II ng/g dw	endrin ng/g dw	gamma BHC ng/g dw	gamma chlordane ng/g dw	HCB ng/g dw
Imperial Valley J20	S-IV-J20A	<0.0316	1.42	0.133	0.536	<0.0316	0.217	0.443
Imperial Valley J20	S-IV-J20B	<0.0283	1.58	0.112	0.55	<0.0283	0.294	0.481
Imperial Valley J20	S-IV-J20C	0.0293	2.75	0.246	0.79	<0.0278	0.46	0.61
Imperial Valley J20	S-IV-J20D	<0.0274	1.71	0.117	0.589	<0.0274	0.264	0.585
Imperial Valley J20	S-IV-J20E	<0.029	1.98	0.159	1	<0.029	0.383	0.78
Imperial Valley J22	S-IV-J22A	0.0403	1.85	0.0973	0.491	<0.0277	0.424	0.933
Imperial Valley J22	S-IV-J22B	0.053	3	0.14	1.02	<0.0291	0.821	1.55
Imperial Valley J22	S-IV-J22C	<0.0284	3.36	0.121	1.04	<0.0284	0.671	1.84
Imperial Valley J22	S-IV-J22D	<0.029	1.13	0.0758	0.6	<0.029	0.3	0.91
Imperial Valley J22	S-IV-J22E	<0.0276	0.627	<0.0276	0.255	<0.0276	0.228	0.473
Imperial Valley K18	S-IV-K18A	<0.0274	0.165	<0.0274	0.0968	<0.0274	0.0275	0.396
Imperial Valley K18	S-IV-K18B	<0.0275	0.0814	0.0424	0.0825	<0.0275	0.0368	0.566
Imperial Valley K18	S-IV-K18C	<0.028	0.071	<0.028	0.169	<0.028	<0.028	0.47
Imperial Valley K18	S-IV-K18D	<0.028	0.083	<0.028	0.0887	<0.028	<0.028	0.345
Imperial Valley K18	S-IV-K18E	<0.0286	0.0864	<0.0286	0.126	<0.0286	<0.0286	0.334
Sonny Bono NWR	S-SB-420A	0.0448	0.275	0.206	1.51	0.0396	<0.0256	0.277
Sonny Bono NWR	S-SB-420B	0.0485	0.255	0.132	1.3	0.0712	<0.0257	0.279
Sonny Bono NWR	S-SB-420C	0.0648	0.272	0.109	1.28	0.0627	<0.0259	0.29
Sonny Bono NWR	S-SB-420D	0.0682	0.235	0.15	1.28	0.0692	<0.0259	0.237
Sonny Bono NWR	S-SB-420E	0.0346	0.276	0.0314	1.15	0.0566	<0.026	0.256
Kern NWR	S-K-15A	<0.0252	0.227	0.283	0.203	<0.0252	0.167	0.233
Kern NWR	S-K-15B	<0.0267	0.105	<0.0267	<0.0267	<0.0267	0.0788	0.275
Kern NWR	S-K-15C	<0.0261	0.1	<0.0261	0.167	<0.0261	0.127	0.192
Kern NWR	S-K-15D	<0.0261	0.0656	<0.0261	0.0815	<0.0261	0.103	0.111
Kern NWR	S-K-15E	<0.0261	0.0727	0.0727	0.0917	<0.0261	0.058	0.0674

Appendix 2. cont.

Location	Sample	**heptachlor** ng/g dw	**hepta-chlorepoxide** ng/g dw	**mirex** ng/g dw	**oxychlordane** ng/g dw	**o,p'-DDD** ng/g dw	**o,p'-DDE** ng/g dw	**o,p'-DDT** ng/g dw
Imperial Valley J20	S-IV-J20A	<0.0316	<0.0316	0.49	0.363	4.56	1.42	2.29
Imperial Valley J20	S-IV-J20B	0.168	0.0432	0.855	0.381	6.66	1.83	2.99
Imperial Valley J20	S-IV-J20C	0.149	0.0564	1.01	0.591	9	2.8	3.91
Imperial Valley J20	S-IV-J20D	0.0554	0.0598	0.687	0.446	6.49	1.84	3.22
Imperial Valley J20	S-IV-J20E	0.0563	<0.029	1.22	0.368	8.84	2.48	5.32
Imperial Valley J22	S-IV-J22A	0.194	0.0291	0.131	0.251	5.77	1.45	1.34
Imperial Valley J22	S-IV-J22B	0.0966	0.0601	0.547	0.375	16.4	3.13	3.7
Imperial Valley J22	S-IV-J22C	0.296	0.0916	0.714	0.419	15.5	3.05	4.31
Imperial Valley J22	S-IV-J22D	0.338	<0.029	0.261	0.216	5.79	1.59	1.89
Imperial Valley J22	S-IV-J22E	0.175	0.0332	0.0718	0.0497	2.38	0.612	0.914
Imperial Valley K18	S-IV-K18A	0.177	<0.0274	0.0572	0.0473	1.21	0.205	0.536
Imperial Valley K18	S-IV-K18B	0.157	0.0591	0.0468	<0.0275	0.609	0.0636	0.278
Imperial Valley K18	S-IV-K18C	0.195	<0.028	<0.028	<0.028	0.458	0.0327	0.238
Imperial Valley K18	S-IV-K18D	0.166	<0.028	<0.028	<0.028	0.451	0.147	0.397
Imperial Valley K18	S-IV-K18E	0.0945	<0.0286	<0.0286	<0.0286	0.639	0.224	0.47
Sonny Bono NWR	S-SB-420A	0.121	<0.0256	0.35	<0.0256	1.94	0.859	3.05
Sonny Bono NWR	S-SB-420B	<0.0257	<0.0257	0.243	<0.0257	1.94	0.781	2.8
Sonny Bono NWR	S-SB-420C	<0.0259	<0.0259	0.246	<0.0259	2.04	0.844	3.16
Sonny Bono NWR	S-SB-420D	<0.0259	<0.0259	0.176	<0.0259	1.64	0.524	2.46
Sonny Bono NWR	S-SB-420E	<0.026	<0.026	0.156	<0.026	1.74	0.469	2.24
Kern NWR	S-K-15A	0.103	0.0256	0.0943	<0.0252	0.04	0.293	0.3
Kern NWR	S-K-15B	0.0399	<0.0267	0.0464	<0.0267	0.0464	0.0938	0.119
Kern NWR	S-K-15C	0.0475	<0.0261	0.0464	<0.0261	0.0264	0.131	0.229
Kern NWR	S-K-15D	<0.0261	<0.0261	0.0709	<0.0261	0.0646	0.261	0.291
Kern NWR	S-K-15E	0.0495	<0.0261	0.039	<0.0261	<0.0261	0.0927	0.0548

Appendix 2. cont.

Location	Sample	p,p'-DDD ng/g dw	p,p'-DDE ng/g dw	p,p'-DDT ng/g dw	pentachloro-anisole ng/g dw	propham ng/g dw	trans-nonachlor ng/g dw	trifluralin ng/g dw
Imperial Valley J20	S-IV-J20A	2.27	195	6.22	0.124	<0.127	2.01	0.549
Imperial Valley J20	S-IV-J20B	3.22	132	8.37	0.144	<0.113	2.62	1.22
Imperial Valley J20	S-IV-J20C	4.71	345	10.8	0.105	<0.112	3.51	0.835
Imperial Valley J20	S-IV-J20D	3.62	163	9.7	0.416	3.73	2.62	1.3
Imperial Valley J20	S-IV-J20E	5.89	317	18.4	0.0844	<0.115	2.66	0.938
Imperial Valley J22	S-IV-J22A	4.54	119	3.89	0.267	<0.111	1.7	0.85
Imperial Valley J22	S-IV-J22B	8.27	250	10.2	0.1	<0.117	2.96	0.966
Imperial Valley J22	S-IV-J22C	7.36	217	12.5	0.147	<0.112	3.27	0.916
Imperial Valley J22	S-IV-J22D	3.49	103	5.31	0.163	2.39	1.24	1.2
Imperial Valley J22	S-IV-J22E	2.02	62	2.1	0.139	3.25	0.577	1.18
Imperial Valley K18	S-IV-K18A	1.55	21.1	1.69	0.0627	4.3	0.165	0.66
Imperial Valley K18	S-IV-K18B	1.02	22.2	1.03	0.0569	2.6	0.231	0.736
Imperial Valley K18	S-IV-K18C	0.742	17.2	0.947	0.0586	2.28	0.2	0.597
Imperial Valley K18	S-IV-K18D	0.763	11.2	1.48	0.0797	4.47	0.146	0.573
Imperial Valley K18	S-IV-K18E	1.15	20.7	1.96	0.0583	<0.116	0.198	1.12
Sonny Bono NWR	S-SB-420A	2.62	102	9.28	<0.0256	<0.104	0.0605	0.73
Sonny Bono NWR	S-SB-420B	2.55	92.8	8.82	0.032	2.47	0.0691	1.3
Sonny Bono NWR	S-SB-420C	2.98	110	9.63	<0.0259	<0.103	0.0867	0.7
Sonny Bono NWR	S-SB-420D	2.53	66.2	7.79	<0.0259	<0.104	0.0934	0.514
Sonny Bono NWR	S-SB-420E	2.59	60	7.2	0.0293	<0.103	0.0765	0.901
Kern NWR	S-K-15A	0.562	2.76	1.72	0.1	3.44	0.282	<0.0252
Kern NWR	S-K-15B	0.291	0.943	0.858	0.0378	2.28	0.177	<0.0267
Kern NWR	S-K-15C	0.545	1.23	1.74	<0.0261	<0.104	0.182	<0.0261
Kern NWR	S-K-15D	0.786	3.48	4.24	<0.0261	<0.105	0.134	<0.0261
Kern NWR	S-K-15E	0.0643	0.456	0.0959	<0.0261	<0.104	0.176	<0.0261

*Aldicarb, azinophosmethyl, barban, bendiocarb, carbaryl, carbofuran, coumaphos, demeton, diazinon, dichlorvos/naled dimethoate, disulfoton, EPN, ethoprop, fensultothion, fenthion, malathion, merphos/tribufos, methiocarb, methomyl, methylparathion, mevinphos, monocrotophos, naled, oxamyl, parathion, phorate, protothiofos, runnel, sulfotepp, sulprofos, tetrachlorvinphos, tetraethylpyrophosphate, trichloronate, and toxaphene were not detected in any soil samples.

Appendix 3. Concentrations of PCBs* (ng/g dry weight) in soil samples collected from mountain plover wintering sites in California, 2006.

Location	Sample	Cl3-PCB ng/g dw	Cl4-PCB ng/g dw	Cl5-PCB ng/g dw	Cl6-PCB ng/g dw	Cl7-PCB ng/g dw	Cl8-PCB ng/g dw	Cl9-PCB ng/g dw	PCB# 1 ng/g dw
Imperial Valley J20	S-IV-J20A	6.63	1.99	6.69	5.7	5.83	<0.632	<0.632	<0.00632
Imperial Valley J20	S-IV-J20B	8.12	2.65	7.44	7.76	8.26	<0.566	<0.566	0.119
Imperial Valley J20	S-IV-J20C	11.2	4.23	12.8	11.3	12.1	0.741	0>.557	<0.00557
Imperial Valley J20	S-IV-J20D	8.31	3.09	9.79	7.43	9.58	0.568	>0.549	0.0609
Imperial Valley J20	S-IV-J20E	16.8	4.01	11.1	10.1	11.9	0.954	>0.579	0.0879
Imperial Valley J22	S-IV-J22A	4.93	2.91	7.47	6.65	6.87	<0.554	>0.554	0.094
Imperial Valley J22	S-IV-J22B	14.8	5.76	12.8	10.9	13.3	0.804	<0.582	0.0436
Imperial Valley J22	S-IV-J22C	13	5.29	13.2	10.7	12.8	0.94	0.607	<0.00568
Imperial Valley J22	S-IV-J22D	4.53	2.97	6.06	5.49	6.47	<0.579	<0.579	0.0583
Imperial Valley J22	S-IV-J22E	1.63	1.68	2.84	4.09	3.2	<0.552	<0.552	0.0995
Imperial Valley K18	S-IV-K18A	5.37	1.03	1.65	1.87	1.84	<0.548	<0.548	0.0198
Imperial Valley K18	S-IV-K18B	8.93	1.2	0.737	1.79	1.63	<0.551	<0.551	0.0123
Imperial Valley K18	S-IV-K18C	6.44	1.32	0.619	1.34	1.44	<0.561	<0.561	0.0743
Imperial Valley K18	S-IV-K18D	3.34	0.914	0.937	1.48	1.45	<0.561	<0.561	<0.00561
Imperial Valley K18	S-IV-K18E	4.95	1.17	0.928	1.61	1.97	<0.572	<0.572	0.014
Sonny Bono NWR	S-SB-420A	0.892	1.18	2.7	2.71	5.15	0.577	<0.512	0.0323
Sonny Bono NWR	S-SB-420B	0.998	1.37	2.84	2.63	4.95	0.564	<0.514	<0.00514
Sonny Bono NWR	S-SB-420C	1.11	1.25	2.64	2.55	4.76	0.598	<0.518	0.134
Sonny Bono NWR	S-SB-420D	1.1	1.01	2.17	1.97	4.1	0.618	<0.518	<0.00518
Sonny Bono NWR	S-SB-420E	1.07	1.08	2.35	1.95	3.79	0.548	<.521	<0.00521
Kern NWR	S-K-15A	1.54	1.37	1.99	2.43	1.01	<0.504	<0.504	<0.00504
Kern NWR	S-K-15B	1.06	1.28	0.981	1.87	0.955	<0.534	<0.534	<0.00534
Kern NWR	S-K-15C	0.967	0.701	1.47	2.25	0.902	<0.522	<0.522	<0.00522
Kern NWR	S-K-15D	0.583	<0.523	1.04	1.78	0.605	<0.523	<0.523	0.019
Kern NWR	S-K-15E	2.49	0.556	0.826	1.34	<0.521	<0.521	<0.521	<0.00521

Appendix 3. cont.

Location	Sample	PCB# 101/90 ng/g dw	PCB# 105 ng/g dw	PCB# 107 ng/g dw	PCB# 110 ng/g dw	PCB# 118 ng/g dw	PCB# 119 ng/g dw	PCB# 128 ng/g dw	PCB# 129 ng/g dw
Imperial Valley J20	S-IV-J20A	0.218	0.0243	0.126	0.691	0.00766	0.0306	0.567	0.0192
Imperial Valley J20	S-IV-J20B	0.307	0.0296	0.12	0.773	<0.00566	0.145	0.639	<0.00566
Imperial Valley J20	S-IV-J20C	0.446	0.0406	0.172	0.855	<0.00557	0.198	0.919	<0.00557
Imperial Valley J20	S-IV-J20D	0.266	0.0255	0.0952	1.1	<0.00549	0.166	0.864	<0.00549
Imperial Valley J20	S-IV-J20E	0.279	0.0176	0.122	0.809	<0.00579	0.14	1.01	<0.00579
Imperial Valley J22	S-IV-J22A	0.438	0.0459	0.0649	0.445	0.0358	<0.00554	0.936	0.00671
Imperial Valley J22	S-IV-J22B	0.422	0.0353	0.0648	0.628	0.0554	0.135	1.18	0.148
Imperial Valley J22	S-IV-J22C	0.499	0.0619	0.0928	0.805	0.0573	0.144	1.39	0.0321
Imperial Valley J22	S-IV-J22D	0.26	0.0163	0.0723	0.499	0.0664	0.0256	0.818	0.0175
Imperial Valley J22	S-IV-J22E	0.0309	0.0155	<0.00552	0.275	0.14	0.0652	0.485	0.103
Imperial Valley K18	S-IV-K18A	0.0253	<0.00548	<0.00548	0.136	<0.00548	0.0286	0.262	0.0396
Imperial Valley K18	S-IV-K18B	0.0368	0.01	<0.00551	0.0401	<0.00551	<0.00551	0.295	0.103
Imperial Valley K18	S-IV-K18C	0.0282	0.00788	<0.00561	0.0473	<0.00561	<0.00561	0.342	0.0845
Imperial Valley K18	S-IV-K18D	0.0393	<0.00561	<0.00561	0.055	0.0101	<0.00561	0.312	0.0236
Imperial Valley K18	S-IV-K18E	<0.00572	<0.00572	<0.00572	0.042	0.00933	<0.00572	0.322	<0.00572
Sonny Bono NWR	S-SB-420A	<0.00512	<0.00512	0.0229	0.191	<0.00512	<0.00512	0.297	0.0803
Sonny Bono NWR	S-SB-420B	0.0681	0.00826	0.0268	0.275	0.0361	<0.00514	0.296	0.0795
Sonny Bono NWR	S-SB-420C	0.0345	0.0094	0.0334	0.161	<0.00518	<0.00518	0.296	0.0324
Sonny Bono NWR	S-SB-420D	0.0493	0.00944	0.0136	0.0766	<0.00518	<0.00518	0.26	0.0357
Sonny Bono NWR	S-SB-420E	0.0461	0.00524	0.0199	0.169	0.00524	<0.00521	0.235	0.0231
Kern NWR	S-K-15A	0.129	0.0205	0.0502	0.0195	0.0143	0.0676	0.297	<0.00504
Kern NWR	S-K-15B	0.161	0.0173	0.0205	0.027	0.00647	0.0226	0.254	0.00534
Kern NWR	S-K-15C	0.133	0.00949	0.0179	0.0179	0.00633	0.0274	0.401	0.0548
Kern NWR	S-K-15D	0.0571	0.0127	0.0116	0.0571	0.00529	0.019	0.297	0.00847
Kern NWR	S-K-15E	0.101	0.02	0.0158	0.0148	<0.00521	0.0148	0.217	0.00521

Appendix 3. cont.

Location	Sample	PCB# 130 ng/g dw	PCB# 135 ng/g dw	PCB# 136 ng/g dw	PCB# 138/160 ng/g dw	PCB# 141/179 ng/g dw	PCB# 149/123 ng/g dw	PCB# 15 ng/g dw	PCB# 151 ng/g dw
Imperial Valley J20	S-IV-J20A	2.02	0.24	0.171	1.24	0.364	0.378	<0.00632	<0.00632
Imperial Valley J20	S-IV-J20B	2.7	0.282	0.186	1.66	0.457	0.513	<0.00566	0.45
Imperial Valley J20	S-IV-J20C	4.3	0.564	0.198	2.57	0.575	0.74	<0.00557	<0.00557
Imperial Valley J20	S-IV-J20D	2.55	0.301	0.172	1.69	0.416	0.483	<0.00549	<0.00549
Imperial Valley J20	S-IV-J20E	2.98	0.395	0.205	1.99	0.491	0.572	<0.00579	0.694
Imperial Valley J22	S-IV-J22A	2.17	0.469	0.22	0.718	0.424	0.674	<0.00554	<0.00554
Imperial Valley J22	S-IV-J22B	3.84	0.812	0.188	1.41	0.285	1.02	<0.00582	0.481
Imperial Valley J22	S-IV-J22C	3.9	0.743	0.126	1.51	0.298	0.969	<0.00568	<0.00568
Imperial Valley J22	S-IV-J22D	1.81	0.321	0.0909	0.732	0.293	0.478	<0.00579	<0.00579
Imperial Valley J22	S-IV-J22E	1.24	0.112	0.0508	0.568	0.239	0.389	<0.00552	<0.00552
Imperial Valley K18	S-IV-K18A	0.701	0.0231	0.0891	0.293	0.151	0.135	<0.00548	<0.00548
Imperial Valley K18	S-IV-K18B	0.488	<0.00551	0.0201	0.249	0.173	0.111	<0.00551	<0.00551
Imperial Valley K18	S-IV-K18C	0.354	<0.00561	0.0146	0.164	0.133	0.0912	<0.00561	<0.00561
Imperial Valley K18	S-IV-K18D	0.486	0.0539	0.018	0.263	0.129	0.102	<0.00561	<0.00561
Imperial Valley K18	S-IV-K18E	0.539	0.049	0.0163	0.242	0.148	0.127	<0.00572	<0.00572
Sonny Bono NWR	S-SB-420A	0.663	0.0469	0.0657	0.423	0.131	0.126	<0.00512	0.212
Sonny Bono NWR	S-SB-420B	0.601	0.0464	0.064	0.393	0.169	0.136	<0.00514	0.227
Sonny Bono NWR	S-SB-420C	0.625	0.0449	0.0585	0.339	0.126	0.116	0.0115	0.222
Sonny Bono NWR	S-SB-420D	0.531	0.022	0.0367	0.301	0.084	0.107	0.00735	0.147
Sonny Bono NWR	S-SB-420E	0.48	0.0587	0.0493	0.297	0.107	0.123	<0.00521	0.151
Kern NWR	S-K-15A	0.701	0.0471	0.00512	0.503	0.219	0.264	0.0707	<0.00504
Kern NWR	S-K-15B	0.432	0.0809	0.00539	0.299	0.352	0.152	0.0529	<0.00534
Kern NWR	S-K-15C	0.568	0.179	0.00527	0.36	0.151	0.204	0.0696	0.0243
Kern NWR	S-K-15D	0.414	0.141	0.00529	0.326	0.14	0.142	0.0201	0.0434
Kern NWR	S-K-15E	0.35	0.0284	0.00738	0.227	0.159	0.13	0.0306	0.0348

Appendix 3. cont.

Location	Sample	PCB# 153/132 ng/g dw	PCB# 156 ng/g dw	PCB# 157/173/201 ng/g dw	PCB# 158 ng/g dw	PCB# 16/32 ng/g dw	PCB# 166 ng/g dw	PCB# 167 ng/g dw	PCB# 170/190 ng/g dw
Imperial Valley J20	S-IV-J20A	0.416	<0.00632	0.0434	0.0843	0.0588	0.0115	0.175	0.0358
Imperial Valley J20	S-IV-J20B	0.474	<0.00566	<0.00566	0.118	<0.00566	<0.00566	0.238	0.0489
Imperial Valley J20	S-IV-J20C	0.805	<0.00557	<0.00557	0.141	0.235	<0.00557	0.353	0.144
Imperial Valley J20	S-IV-J20D	0.495	<0.00549	<0.00549	0.117	<0.00549	<0.00549	0.32	0.0631
Imperial Valley J20	S-IV-J20E	0.735	<0.00579	<0.00579	0.121	0.236	0.0328	0.347	0.217
Imperial Valley J22	S-IV-J22A	0.415	0.0112	0.0257	0.0716	0.246	0.0112	0.523	0.123
Imperial Valley J22	S-IV-J22B	0.66	0.164	0.0471	0.23	0.408	0.00589	0.463	0.152
Imperial Valley J22	S-IV-J22C	0.777	0.079	0.0527	0.111	0.129	0.00573	0.788	0.186
Imperial Valley J22	S-IV-J22D	0.3	0.0373	0.0326	0.0699	0.255	<0.00579	0.517	0.155
Imperial Valley J22	S-IV-J22E	0.313	0.259	0.0409	0.108	0.356	<0.00552	0.134	0.0862
Imperial Valley K18	S-IV-K18A	0.0814	<0.00548	0.0209	0.0374	0.228	<0.00548	0.0627	0.0715
Imperial Valley K18	S-IV-K18B	0.0903	0.128	0.0312	0.0346	0.298	<0.00551	0.068	0.146
Imperial Valley K18	S-IV-K18C	0.0721	<0.00561	0.0158	0.0169	0.259	<0.00561	0.0338	0.106
Imperial Valley K18	S-IV-K18D	0.0875	<0.00561	0.0314	<0.00561	0.169	<0.00561	<0.00561	0.0965
Imperial Valley K18	S-IV-K18E	0.0712	<0.00572	0.0233	0.007	0.3	<0.00572	0.0898	0.167
Sonny Bono NWR	S-SB-420A	0.109	<0.00512	0.0282	0.0626	0.128	<0.00512	0.363	0.0354
Sonny Bono NWR	S-SB-420B	0.185	<0.00514	0.0248	0.0475	0.0836	<0.00514	0.312	0.0351
Sonny Bono NWR	S-SB-420C	0.168	0.0178	0.0366	0.0261	0.15	0.0125	0.359	0.0491
Sonny Bono NWR	S-SB-420D	0.139	0.0178	0.0273	0.0241	0.151	0.0063	0.256	0.0315
Sonny Bono NWR	S-SB-420E	0.132	0.00839	0.0335	0.0262	0.135	0.00839	0.254	0.0252
Kern NWR	S-K-15A	0.272	0.0379	<0.00504	0.0082	0.965	0.0123	0.0646	0.00615
Kern NWR	S-K-15B	0.174	<0.00534	0.0432	<0.00534	0.565	<0.00534	0.0636	0.0388
Kern NWR	S-K-15C	0.178	0.00527	0.00633	0.00633	0.637	0.0148	0.0981	0.0137
Kern NWR	S-K-15D	0.161	0.00741	0.00847	0.00529	0.276	<0.00523	0.0698	0.0127
Kern NWR	S-K-15E	0.124	<0.00521	0.0126	0.00738	2	<0.00521	0.0527	0.00948

Appendix 3. cont.

Location	Sample	PCB# 171/202 ng/g dw	PCB# 172 ng/g dw	PCB# 174 ng/g dw	PCB# 175 ng/g dw	PCB# 176/137 ng/g dw	PCB# 177 ng/g dw	PCB# 178 ng/g dw	PCB# 18/17 ng/g dw
Imperial Valley J20	S-IV-J20A	<0.00632	<0.00632	0.0549	0.147	0.163	0.105	0.548	<0.00632
Imperial Valley J20	S-IV-J20B	0.0375	0.058	0.0852	0.175	0.289	0.144	0.753	<0.00566
Imperial Valley J20	S-IV-J20C	0.139	0.118	0.0924	0.284	0.319	<0.00557	1.03	<0.00557
Imperial Valley J20	S-IV-J20D	0.185	0.156	0.0831	0.189	0.496	<0.00549	0.75	<0.00549
Imperial Valley J20	S-IV-J20E	0.0363	0.147	0.0973	0.297	0.477	<0.00579	0.965	0.0973
Imperial Valley J22	S-IV-J22A	0.0336	0.0492	0.0895	0.164	0.175	0.104	0.642	0.101
Imperial Valley J22	S-IV-J22B	0.0306	0.0224	0.105	0.282	0.346	0.0919	1.48	0.053
Imperial Valley J22	S-IV-J22C	0.00573	0.047	0.0939	0.273	0.328	0.108	1.31	0.0596
Imperial Valley J22	S-IV-J22D	0.0256	0.0245	0.0629	0.15	0.223	0.118	0.603	0.0944
Imperial Valley J22	S-IV-J22E	0.00773	0.0387	0.0608	0.0983	0.169	0.0774	0.269	<0.00552
Imperial Valley K18	S-IV-K18A	<0.00548	0.0099	0.0132	0.066	0.163	0.0803	0.107	0.109
Imperial Valley K18	S-IV-K18B	0.0078	0.0279	0.0223	0.0636	0.192	0.0847	0.0925	0.201
Imperial Valley K18	S-IV-K18C	0.00676	0.0158	0.0135	0.0574	0.167	0.0957	0.071	0.0372
Imperial Valley K18	S-IV-K18D	0.0314	0.00786	0.0707	0.0539	0.139	0.104	0.073	<0.00561
Imperial Valley K18	S-IV-K18E	0.0187	0.0128	0.0513	0.0642	0.247	0.0642	0.106	<0.00572
Sonny Bono NWR	S-SB-420A	0.0282	0.0167	0.073	0.103	0.0949	0.072	0.36	0.0751
Sonny Bono NWR	S-SB-420B	0.033	0.0103	0.0712	0.0929	0.0836	0.0898	0.291	0.0846
Sonny Bono NWR	S-SB-420C	0.0408	0.0104	0.0679	0.115	0.00731	0.094	0.311	0.0554
Sonny Bono NWR	S-SB-420D	0.0493	0.0168	0.0724	0.0913	0.0556	0.0986	0.221	0.129
Sonny Bono NWR	S-SB-420E	0.0367	0.0105	0.0734	0.0828	0.0356	0.124	0.207	0.0398
Kern NWR	S-K-15A	0.0215	0.041	0.0369	0.0768	0.0973	0.204	0.0133	0.0471
Kern NWR	S-K-15B	0.0291	0.041	0.0205	0.0561	0.0442	0.42	0.00539	0.0313
Kern NWR	S-K-15C	0.00949	0.0422	0.019	0.0707	0.0844	0.121	0.0707	0.0232
Kern NWR	S-K-15D	0.00847	0.0148	0.0212	0.0709	0.0635	0.0487	0.00529	0.0222
Kern NWR	S-K-15E	0.0158	0.0432	0.0148	0.0548	0.0327	0.0864	<0.00521	0.0179

Appendix 3. cont.

Location	Sample	PCB# 180 ng/g dw	PCB# 183 ng/g dw	PCB# 185 ng/g dw	PCB# 187 ng/g dw	PCB# 189 ng/g dw	PCB# 191 ng/g dw	PCB# 193 ng/g dw	PCB# 194 ng/g dw
Imperial Valley J20	S-IV-J20A	0.0255	3.94	0.307	0.354	<0.00632	<0.00632	0.139	<0.00632
Imperial Valley J20	S-IV-J20B	0.0989	6.03	0.433	0.0102	<0.00566	0.0204	0.0841	<0.00566
Imperial Valley J20	S-IV-J20C	0.0552	8.88	0.684	0.0169	0.0564	0.0609	0.165	<0.00557
Imperial Valley J20	S-IV-J20D	0.0277	6.71	0.495	0.00997	0.0321	0.0244	0.364	<0.00549
Imperial Valley J20	S-IV-J20E	0.0492	8.37	0.496	0.0352	0.0586	0.0199	0.614	0.135
Imperial Valley J22	S-IV-J22A	0.0805	4.42	0.619	0.301	0.00783	<0.00554	0.0548	0.0548
Imperial Valley J22	S-IV-J22B	0.053	9.18	0.631	0.733	0.0495	<0.00582	0.101	0.066
Imperial Valley J22	S-IV-J22C	0.0561	8.62	0.747	0.821	0.0412	<0.00568	0.12	0.215
Imperial Valley J22	S-IV-J22D	0.0664	4.24	0.425	0.307	0.00583	<0.00579	0.0618	0.0291
Imperial Valley J22	S-IV-J22E	0.135	1.85	0.211	0.16	0.00663	0.00663	0.0309	0.0497
Imperial Valley K18	S-IV-K18A	0.0671	0.998	0.0891	0.077	0.0099	0.0066	0.077	0.0121
Imperial Valley K18	S-IV-K18B	0.0223	0.715	0.0847	0.0691	0.00557	0.00892	0.0847	0.0279
Imperial Valley K18	S-IV-K18C	0.0248	0.636	0.08	0.0642	0.0203	0.00788	0.0777	0.0124
Imperial Valley K18	S-IV-K18D	0.0247	0.64	0.0651	0.0415	0.00898	<0.00561	0.0954	0.00561
Imperial Valley K18	S-IV-K18E	0.0408	0.782	0.0898	0.107	0.0257	<0.00572	0.189	0.0338
Sonny Bono NWR	S-SB-420A	0.0188	3.98	0.105	0.166	0.0229	<0.00512	0.074	<0.00512
Sonny Bono NWR	S-SB-420B	0.0402	3.88	0.096	0.142	0.0279	<0.00514	0.0568	<0.00514
Sonny Bono NWR	S-SB-420C	0.0136	3.71	0.112	0.152	0.0146	<0.00518	0.0616	<0.00518
Sonny Bono NWR	S-SB-420D	0.0304	3.15	0.0871	0.116	0.0189	<0.00518	0.0504	<0.00518
Sonny Bono NWR	S-SB-420E	0.0157	2.94	0.0849	0.086	0.0178	<0.00521	0.0472	<0.00521
Kern NWR	S-K-15A	0.0768	0.106	0.112	0.145	0.0123	<0.00504	0.0564	0.0266
Kern NWR	S-K-15B	0.0755	0.0626	0.0518	0.0529	0.00755	0.00539	0.0464	0.0647
Kern NWR	S-K-15C	0.057	0.148	0.077	0.111	0.0106	<0.00522	0.0654	0.0232
Kern NWR	S-K-15D	0.0656	0.101	0.0582	0.0762	0.00952	<0.00523	0.0487	0.00952
Kern NWR	S-K-15E	0.0485	0.0316	0.0622	0.0601	<0.00521	0.00527	0.019	0.0158

Appendix 3. cont.

Location	Sample	PCB# 195/208 ng/g dw	PCB# 196 ng/g dw	PCB# 197 ng/g dw	PCB# 199 ng/g dw	PCB# 200 ng/g dw	PCB# 205 ng/g dw	PCB# 206 ng/g dw	PCB# 207 ng/g dw
Imperial Valley J20	S-IV-J20A	0.0179	0.0447	0.0192	0.166	<0.00632	0.0422	0.0881	0.103
Imperial Valley J20	S-IV-J20B	<0.00566	0.142	0.0216	0.249	<0.00566	0.108	0.0989	0.147
Imperial Valley J20	S-IV-J20C	<0.00557	0.257	0.0406	0.371	<0.00557	0.0733	0.266	0.216
Imperial Valley J20	S-IV-J20D	<0.00549	0.192	0.0831	0.24	<0.00549	0.0532	0.184	0.157
Imperial Valley J20	S-IV-J20E	0.00586	0.286	0.0293	0.397	0.0434	0.0574	0.236	0.209
Imperial Valley J22	S-IV-J22A	0.0447	0.0212	<0.00554	0.197	0.0392	0.0302	0.0447	0.0101
Imperial Valley J22	S-IV-J22B	0.0554	0.0424	0.0471	0.45	0.0165	0.0801	0.309	0.252
Imperial Valley J22	S-IV-J22C	0.0458	0.0756	0.0321	0.432	0.0114	0.0768	0.275	0.332
Imperial Valley J22	S-IV-J22D	0.0676	0.0198	<0.00579	0.235	<0.00579	0.0525	0.0466	0.0268
Imperial Valley J22	S-IV-J22E	<0.00552	0.108	0.0177	0.122	<0.00552	0.0508	0.255	0.0365
Imperial Valley K18	S-IV-K18A	<0.00548	0.0583	0.0132	0.228	<0.00548	0.0253	0.0649	<0.00548
Imperial Valley K18	S-IV-K18B	<0.00551	0.019	0.0223	0.402	0.00669	0.0178	0.167	<0.00551
Imperial Valley K18	S-IV-K18C	<0.00561	0.0293	0.0191	0.375	0.00676	0.0135	0.16	<0.00561
Imperial Valley K18	S-IV-K18D	<0.00561	<0.00561	0.00898	0.239	<0.00561	0.0449	0.0606	0.0101
Imperial Valley K18	S-IV-K18E	<0.00572	<0.00572	0.00933	0.238	<0.00572	0.028	0.132	0.00933
Sonny Bono NWR	S-SB-420A	<0.00512	0.0438	0.0667	0.424	<0.00512	0.0115	0.0709	0.0521
Sonny Bono NWR	S-SB-420B	<0.00514	0.0485	0.0733	0.4	<0.00514	0.0175	0.031	<0.00514
Sonny Bono NWR	S-SB-420C	0.00627	0.0491	0.0732	0.398	0.0104	0.023	<0.00518	<0.00518
Sonny Bono NWR	S-SB-420D	0.00735	0.0588	0.0598	0.437	0.0126	0.0136	0.0063	<0.00518
Sonny Bono NWR	S-SB-420E	0.00521	0.0388	0.065	0.382	0.0126	0.0115	<0.00521	<0.00521
Kern NWR	S-K-15A	0.0082	0.0891	0.0102	0.0256	0.0164	0.11	0.04	<0.00504
Kern NWR	S-K-15B	0.00863	0.0464	0.0119	0.125	0.0162	0.147	0.0895	<0.00534
Kern NWR	S-K-15C	0.0158	0.0422	0.0222	0.0137	0.0116	0.0939	0.0369	<0.00522
Kern NWR	S-K-15D	0.00847	0.019	0.00635	0.018	<0.00523	0.0339	0.0148	0.018
Kern NWR	S-K-15E	0.00632	0.0664	0.00738	0.0158	0.00632	0.0432	0.0169	<0.00521

Appendix 3. cont.

Location	Sample	PCB# 209 ng/g dw	PCB# 22/51 ng/g dw	PCB# 24/27 ng/g dw	PCB# 25 ng/g dw	PCB# 26 ng/g dw	PCB# 28 ng/g dw	PCB# 29 ng/g dw	PCB# 30 ng/g dw
Imperial Valley J20	S-IV-J20A	<0.00632	<0.00632	<0.00632	<0.00632	0.198	0.0907	5.76	<0.00632
Imperial Valley J20	S-IV-J20B	0.0148	0.0307	0.0114	<0.00566	0.241	0.589	6.74	<0.00566
Imperial Valley J20	S-IV-J20C	0.0519	0.0406	0.0361	<0.00557	<0.00557	0.445	10.2	0.0541
Imperial Valley J20	S-IV-J20D	0.0487	0.00886	0.00886	<0.00549	0.0775	0.698	7.48	<0.00549
Imperial Valley J20	S-IV-J20E	0.0879	0.0516	0.0316	<0.00579	0.149	0.198	16	<0.00579
Imperial Valley J22	S-IV-J22A	0.0962	0.103	<0.00554	0.0705	0.372	0.661	2.26	0.372
Imperial Valley J22	S-IV-J22B	0.0978	0.174	<0.00582	0.0294	0.15	0.224	12.1	0.0907
Imperial Valley J22	S-IV-J22C	0.166	0.32	<0.00568	0.0596	0.307	0.255	10.9	0.15
Imperial Valley J22	S-IV-J22D	0.035	0.0792	0.0454	0.0373	0.0723	0.279	2.65	0.507
Imperial Valley J22	S-IV-J22E	0.0398	0.0354	0.011	<0.00552	<0.00552	0.134	0.864	0.0243
Imperial Valley K18	S-IV-K18A	0.0198	0.0099	0.0561	0.022	0.108	0.29	3.89	0.0187
Imperial Valley K18	S-IV-K18B	0.0123	0.0424	0.0201	<0.00551	0.106	0.184	7.51	<0.00551
Imperial Valley K18	S-IV-K18C	0.0214	0.0124	0.036	<0.00561	0.101	0.233	5.29	<0.00561
Imperial Valley K18	S-IV-K18D	0.118	0.00898	<0.00561	<0.00561	0.0584	0.15	2.62	<0.00561
Imperial Valley K18	S-IV-K18E	0.0653	0.0128	<0.00572	<0.00572	0.0432	0.261	3.86	<0.00572
Sonny Bono NWR	S-SB-420A	0.0073	0.0198	<0.00512	<0.00512	0.025	0.0365	0.593	<0.00512
Sonny Bono NWR	S-SB-420B	0.0134	0.0155	<0.00514	<0.00514	0.0351	0.0248	0.695	<0.00514
Sonny Bono NWR	S-SB-420C	0.0125	0.00627	<0.00518	<0.00518	0.0428	0.0251	0.717	<0.00518
Sonny Bono NWR	S-SB-420D	0.00944	0.00839	<0.00518	<0.00518	0.022	0.0556	0.717	<0.00518
Sonny Bono NWR	S-SB-420E	0.0115	0.0136	0.00629	<0.00521	0.0451	0.0126	0.77	<0.00521
Kern NWR	S-K-15A	0.0441	<0.00504	0.0133	<0.00504	0.0195	<0.00504	0.395	0.00922
Kern NWR	S-K-15B	0.0496	0.0658	0.00755	<0.00534	<0.00534	0.0421	0.175	<0.00534
Kern NWR	S-K-15C	0.0338	0.0316	0.0158	<0.00522	0.00844	<0.00522	0.152	<0.00522
Kern NWR	S-K-15D	0.0127	<0.00523	0.00741	<0.00523	<0.00523	0.0328	0.114	<0.00523
Kern NWR	S-K-15E	0.0116	0.04	<0.00521	<0.00521	<0.00521	0.0179	0.337	<0.00521

Appendix 3. cont.

Location	Sample	PCB# 31 ng/g dw	PCB# 33/20 ng/g dw	PCB# 39 ng/g dw	PCB# 40 ng/g dw	PCB# 41/64 ng/g dw	PCB# 42/59/37 ng/g dw	PCB# 44 ng/g dw	PCB# 45 ng/g dw
Imperial Valley J20	S-IV-J20A	0.525	<0.00632	<0.00632	0.0332	8.66	0.0511	0.155	<0.00632
Imperial Valley J20	S-IV-J20B	0.484	0.0239	<0.00566	0.0352	5.01	<0.00566	0.215	0.0602
Imperial Valley J20	S-IV-J20C	<0.00557	0.143	<0.00557	0.105	6.28	<0.00557	0.205	0.0496
Imperial Valley J20	S-IV-J20D	<0.00549	0.0365	<0.00549	0.0299	9.21	<0.00549	0.22	0.0532
Imperial Valley J20	S-IV-J20E	<0.00579	0.0551	<0.00579	0.0598	11.3	<0.00579	0.204	0.0516
Imperial Valley J22	S-IV-J22A	0.63	0.0168	0.0906	<0.00554	145	<0.00554	0.15	<0.00554
Imperial Valley J22	S-IV-J22B	1.49	0.0353	0.0436	0.284	70.7	<0.00582	0.266	0.0766
Imperial Valley J22	S-IV-J22C	0.656	0.0252	0.12	0.0596	58.6	<0.00568	0.249	0.055
Imperial Valley J22	S-IV-J22D	0.383	0.0268	0.103	<0.00579	47.8	<0.00579	0.212	0.0653
Imperial Valley J22	S-IV-J22E	0.137	0.0199	0.0541	<0.00552	63	0.0155	0.218	0.0486
Imperial Valley K18	S-IV-K18A	0.568	0.0187	0.0528	<0.00548	43.7	0.0099	0.199	0.0374
Imperial Valley K18	S-IV-K18B	0.537	0.0312	<0.00551	<0.00551	69.2	0.0245	0.178	<0.00551
Imperial Valley K18	S-IV-K18C	0.413	0.0304	0.0349	<0.00561	72.9	0.306	0.13	0.0439
Imperial Valley K18	S-IV-K18D	0.311	0.0258	<0.00561	<0.00561	36.4	<0.00561	0.159	0.0494
Imperial Valley K18	S-IV-K18E	0.445	0.028	<0.00572	<0.00572	38.6	<0.00572	0.194	0.028
Sonny Bono NWR	S-SB-420A	<0.00512	0.0136	<0.00512	0.072	6.74	<0.00512	0.181	<0.00512
Sonny Bono NWR	S-SB-420B	0.0588	<0.00514	<0.00514	0.0134	4.72	0.0237	0.184	<0.00514
Sonny Bono NWR	S-SB-420C	0.0742	0.0324	<0.00518	0.024	4.02	<0.00518	0.191	0.00522
Sonny Bono NWR	S-SB-420D	<0.00518	0.0189	<0.00518	0.0199	4.23	<0.00518	0.173	0.0346
Sonny Bono NWR	S-SB-420E	0.0314	0.0168	<0.00521	0.0314	5.25	<0.00521	0.17	0.0335
Kern NWR	S-K-15A	0.0266	0.0482	0.0154	0.0533	<0.00504	0.0174	0.292	0.0318
Kern NWR	S-K-15B	0.124	0.0194	0.0259	<0.00534	<0.00534	0.00863	0.277	0.0216
Kern NWR	S-K-15C	0.0443	0.0338	0.02	0.0264	<0.00522	0.00633	0.276	0.0264
Kern NWR	S-K-15D	0.116	0.00847	<0.00523	0.0127	<0.00523	0.00529	0.201	<0.00523
Kern NWR	S-K-15E	0.0327	0.0348	<0.00521	<0.00521	<0.00521	0.0126	0.23	0.0348

Appendix 3. cont.

Location	Sample	PCB# 46 ng/g dw	PCB# 47/75 ng/g dw	PCB# 48 ng/g dw	PCB# 49 ng/g dw	PCB# 52 ng/g dw	PCB# 53 ng/g dw	PCB# 60/56 ng/g dw	PCB# 63 ng/g dw
Imperial Valley J20	S-IV-J20A	0.313	0.12	<0.00632	0.0115	0.16	<0.00632	<0.00632	<0.00632
Imperial Valley J20	S-IV-J20B	0.255	<0.00566	<0.00566	0.1	0.292	<0.00566	<0.00566	<0.00566
Imperial Valley J20	S-IV-J20C	0.541	0.219	<0.00557	<0.00557	0.309	<0.00557	<0.00557	<0.00557
Imperial Valley J20	S-IV-J20D	0.466	<0.00549	<0.00549	0.0997	0.279	<0.00549	<0.00549	<0.00549
Imperial Valley J20	S-IV-J20E	0.986	0.109	0.0129	<0.00579	0.369	<0.00579	<0.00579	<0.00579
Imperial Valley J22	S-IV-J22A	0.254	<0.00554	0.00554	0.182	0.0492	<0.00554	0.31	<0.00554
Imperial Valley J22	S-IV-J22B	0.816	0.0189	0.00582	0.231	0.551	<0.00582	0.371	<0.00582
Imperial Valley J22	S-IV-J22C	0.717	0.0527	0.00568	0.197	0.433	<0.00568	0.314	<0.00568
Imperial Valley J22	S-IV-J22D	0.178	0.0571	0.00579	0.177	0.282	<0.00579	0.432	<0.00579
Imperial Valley J22	S-IV-J22E	0.0873	<0.00552	0.00552	0.0332	0.0729	<0.00552	<0.00552	<0.00552
Imperial Valley K18	S-IV-K18A	0.0594	<0.00548	0.00548	0.169	0.0506	<0.00548	<0.00548	<0.00548
Imperial Valley K18	S-IV-K18B	0.117	0.0178	<0.00551	0.0758	0.162	<0.00551	<0.00551	<0.00551
Imperial Valley K18	S-IV-K18C	0.14	<0.00561	<0.00561	0.0394	0.0372	<0.00561	<0.00561	<0.00561
Imperial Valley K18	S-IV-K18D	0.0673	<0.00561	<0.00561	0.0191	0.0348	<0.00561	<0.00561	<0.00561
Imperial Valley K18	S-IV-K18E	0.0875	0.0338	<0.00572	0.0152	0.042	<0.00572	<0.00572	<0.00572
Sonny Bono NWR	S-SB-420A	0.122	<0.00512	<0.00512	0.0125	0.0469	<0.00512	<0.00512	<0.00512
Sonny Bono NWR	S-SB-420B	0.0557	<0.00514	<0.00514	0.0165	0.115	<0.00514	<0.00514	<0.00514
Sonny Bono NWR	S-SB-420C	0.101	0.00522	<0.00518	0.0125	0.0418	<0.00518	<0.00518	0.00836
Sonny Bono NWR	S-SB-420D	0.0934	0.00735	<0.00518	0.0168	0.0346	<0.00518	<0.00518	0.00839
Sonny Bono NWR	S-SB-420E	0.0702	0.0178	<0.00521	0.022	0.043	<0.00521	<0.00521	0.00629
Kern NWR	S-K-15A	0.0164	0.118	0.121	0.0338	0.04	<0.00504	0.127	0.0307
Kern NWR	S-K-15B	0.0151	0.0281	<0.00534	0.0173	0.0723	<0.00534	0.134	0.00863
Kern NWR	S-K-15C	0.00633	0.0232	0.0401	0.0169	0.0179	<0.00522	<0.00522	0.0148
Kern NWR	S-K-15D	0.0106	0.0222	0.0328	0.0254	0.00741	0.0138	0.0286	<0.00523
Kern NWR	S-K-15E	0.00527	0.0316	<0.00521	0.0274	0.00948	<0.00521	0.04	<0.00521

Appendix 3. cont.

Location	Sample	PCB# 66 ng/g dw	PCB# 67 ng/g dw	PCB# 7/9 ng/g dw	PCB# 70 ng/g dw	PCB# 72 ng/g dw	PCB# 74/61 ng/g dw	PCB# 8/5 ng/g dw	PCB# 82 ng/g dw
Imperial Valley J20	S-IV-J20A	0.0677	0.0613	<0.00632	0.105	0.752	0.0358	0.0128	1.77
Imperial Valley J20	S-IV-J20B	0.126	0.293	<0.00566	0.18	0.928	0.05	0.233	2.48
Imperial Valley J20	S-IV-J20C	0.331	0.493	<0.00557	0.374	1.04	0.159	0.177	3.69
Imperial Valley J20	S-IV-J20D	0.255	0.279	<0.00549	0.235	0.96	0.0709	0.295	2.45
Imperial Valley J20	S-IV-J20E	<0.00579	0.182	<0.00579	0.318	1.41	0.0903	0.281	2.92
Imperial Valley J22	S-IV-J22A	0.3	0.276	0.123	0.152	0.978	0.116	0.336	1.88
Imperial Valley J22	S-IV-J22B	0.37	0.391	<0.00582	0.29	1.52	0.233	0.355	3.57
Imperial Valley J22	S-IV-J22C	0.43	0.521	<0.00568	0.299	1.49	0.235	0.389	3.62
Imperial Valley J22	S-IV-J22D	0.307	0.284	<0.00579	0.119	0.674	0.0851	0.302	1.67
Imperial Valley J22	S-IV-J22E	0.169	0.032	<0.00552	0.11	0.791	0.0409	0.197	0.93
Imperial Valley K18	S-IV-K18A	0.0583	<0.00548	<0.00548	0.0968	0.294	0.055	0.239	0.437
Imperial Valley K18	S-IV-K18B	0.0903	0.0156	<0.00551	0.101	0.372	0.0424	0.243	0.314
Imperial Valley K18	S-IV-K18C	0.0957	0.0146	<0.00561	0.106	0.37	0.0394	0.253	0.309
Imperial Valley K18	S-IV-K18D	0.204	<0.00561	<0.00561	0.00673	0.323	0.0483	0.221	0.276
Imperial Valley K18	S-IV-K18E	0.0688	<0.00572	<0.00572	0.0187	0.63	0.049	0.215	0.386
Sonny Bono NWR	S-SB-420A	0.0605	<0.00512	<0.00512	0.0156	0.575	0.0949	0.234	0.791
Sonny Bono NWR	S-SB-420B	0.114	<0.00514	<0.00514	0.031	0.709	0.109	0.209	0.771
Sonny Bono NWR	S-SB-420C	0.0648	0.00731	<0.00518	0.0199	0.702	0.0711	0.107	0.771
Sonny Bono NWR	S-SB-420D	0.0682	0.0063	<0.00518	0.0315	0.426	0.0787	0.084	0.573
Sonny Bono NWR	S-SB-420E	0.0786	0.00839	<0.00521	0.021	0.527	0.0493	0.108	0.601
Kern NWR	S-K-15A	0.0984	0.0656	<0.00504	0.0891	0.133	0.0686	0.0994	0.75
Kern NWR	S-K-15B	0.0561	0.0647	<0.00534	0.0485	0.166	0.159	0.0906	0.29
Kern NWR	S-K-15C	0.0454	0.0443	<0.00522	0.0327	0.0464	0.0422	0.096	0.543
Kern NWR	S-K-15D	0.0243	0.0529	<0.00523	0.019	<0.00523	0.00952	0.0656	0.462
Kern NWR	S-K-15E	0.019	0.0432	<0.00521	0.0337	0.00843	0.058	0.0527	0.322

Appendix 3. cont.

Location	Sample	PCB# 83 ng/g dw	PCB# 84 ng/g dw	PCB# 85 ng/g dw	PCB# 87/115 ng/g dw	PCB# 92 ng/g dw	PCB# 95/80 ng/g dw	PCB# 97 ng/g dw	PCB# 99 ng/g dw
Imperial Valley J20	S-IV-J20A	0.0524	1.6	0.0358	0.158	0.926	0.221	0.718	0.105
Imperial Valley J20	S-IV-J20B	0.177	1.8	0.0955	0.201	<0.00566	<0.00566	0.984	0.324
Imperial Valley J20	S-IV-J20C	0.156	2.76	0.0676	0.295	2.18	<0.00557	1.46	0.446
Imperial Valley J20	S-IV-J20D	0.196	1.73	0.062	0.212	1.55	0.529	1.01	0.401
Imperial Valley J20	S-IV-J20E	0.25	1.69	0.0574	0.26	2.9	<0.00579	1.28	0.428
Imperial Valley J22	S-IV-J22A	0.00783	1.2	0.122	0.202	0.508	0.34	1.51	0.668
Imperial Valley J22	S-IV-J22B	0.119	1.95	0.105	0.305	2.24	0.649	2.11	0.371
Imperial Valley J22	S-IV-J22C	0.136	2.28	0.147	0.292	2.2	0.536	1.97	0.409
Imperial Valley J22	S-IV-J22D	0.0373	0.904	0.0758	0.154	0.781	0.558	0.881	0.0688
Imperial Valley J22	S-IV-J22E	0.074	0.256	0.0995	0.191	<0.00552	<0.00552	0.681	0.0751
Imperial Valley K18	S-IV-K18A	0.0429	0.0528	0.0176	0.0858	0.244	0.12	0.372	0.0847
Imperial Valley K18	S-IV-K18B	<0.00551	0.0814	0.039	0.0424	<0.00551	<0.00551	0.144	0.0279
Imperial Valley K18	S-IV-K18C	0.018	0.054	<0.00561	0.0439	<0.00561	<0.00561	0.0856	0.027
Imperial Valley K18	S-IV-K18D	0.0337	0.055	0.00786	0.0505	0.242	<0.00561	0.119	0.0438
Imperial Valley K18	S-IV-K18E	0.0292	0.0502	0.00817	0.0665	0.123	<0.00572	0.179	0.0315
Sonny Bono NWR	S-SB-420A	0.049	<0.00512	0.00938	0.0688	1.16	<0.00512	0.332	0.0772
Sonny Bono NWR	S-SB-420B	0.0495	<0.00514	0.00929	0.0867	1.06	0.0836	0.287	0.0846
Sonny Bono NWR	S-SB-420C	0.047	<0.00518	0.00627	0.0711	1.2	<0.00518	0.304	<0.00518
Sonny Bono NWR	S-SB-420D	0.0346	0.0818	<0.00518	0.0556	0.977	<0.00518	0.242	0.0504
Sonny Bono NWR	S-SB-420E	0.0377	0.102	0.00629	0.0566	1.01	<0.00521	0.245	0.0451
Kern NWR	S-K-15A	0.193	0.409	0.0256	0.154	<0.00504	0.0533	<0.00504	0.0471
Kern NWR	S-K-15B	0.12	0.184	0.0281	0.0367	<0.00534	0.0281	<0.00534	0.0259
Kern NWR	S-K-15C	0.141	0.258	0.02	0.149	<0.00522	0.039	<0.00522	0.0802
Kern NWR	S-K-15D	0.0529	0.135	0.00847	0.101	0.054	0.0148	<0.00523	0.0381
Kern NWR	S-K-15E	0.0379	0.227	0.00948	0.0337	<0.00521	0.0158	<0.00521	<0.00521

Appendix 3. cont.

Location	Sample	PCB-1268 ng/g dw	PCB-TOTAL ng/g dw
Imperial Valley J20	S-IV-J20A	27.4	27.3
Imperial Valley J20	S-IV-J20B	35.4	35.3
Imperial Valley J20	S-IV-J20C	53	53
Imperial Valley J20	S-IV-J20D	39.5	39.5
Imperial Valley J20	S-IV-J20E	55.7	55.8
Imperial Valley J22	S-IV-J22A	29.9	30
Imperial Valley J22	S-IV-J22B	59.4	59.4
Imperial Valley J22	S-IV-J22C	57.1	57.2
Imperial Valley J22	S-IV-J22D	26.4	26.5
Imperial Valley J22	S-IV-J22E	14.5	14.5
Imperial Valley K18	S-IV-K18A	12.5	12.4
Imperial Valley K18	S-IV-K18B	15.2	15.3
Imperial Valley K18	S-IV-K18C	12.2	12.2
Imperial Valley K18	S-IV-K18D	8.87	8.87
Imperial Valley K18	S-IV-K18E	11.4	11.4
Sonny Bono NWR	S-SB-420A	13.6	13.7
Sonny Bono NWR	S-SB-420B	13.6	13.6
Sonny Bono NWR	S-SB-420C	13.2	13.2
Sonny Bono NWR	S-SB-420D	11.1	11.1
Sonny Bono NWR	S-SB-420E	10.9	10.9
Kern NWR	S-K-15A	8.88	8.91
Kern NWR	S-K-15B	6.89	6.9
Kern NWR	S-K-15C	6.76	6.75
Kern NWR	S-K-15D	4.76	4.76
Kern NWR	S-K-15E	5.99	6.01

* Cl1-PCB, Cl10-PCB, Cl2-PCB, PCB#114, PCB#126, PCB#146, PCB#169, PCB#69, PCB#77, PCB #81, PCB-1242, PCB-1248, PCB#1254, and PCB 1260 not detected in any soil samples.

Appendix 4. Concentrations of inorganics* (ug/g dry weight) in terrestrial invertebrate samples collected from mountain plover wintering sites in California, 2006.

Location	Sample	Moisture %	Al ug/g dw	As ug/g dw	B ug/g dw	Ba ug/g dw	Be ug/g dw	Cd ug/g dw	Cr ug/g dw	Cu ug/g dw
Imperial Valley J20	I-IV-J20A	54.8	190	<0.3	20	1.8	<0.1	0.2	<0.5	25
Imperial Valley J20	I-IV-J20B	56.2	3120	1.4	10	47.8	<0.1	0.84	3.5	94.9
Imperial Valley J20	I-IV-J20C	57	480	<0.8	<20	5.6	<0.1	0.6	<0.7	57
Imperial Valley J20	I-IV-J20D	59.3	1010	0.4	<10	10	<0.1	0.5	1	62.8
Imperial Valley J20	I-IV-J20E	42.3	150	<0.7	<20	2.4	<0.1	0.5	<0.6	42
Imperial Valley J22	I-IV-J22A	61.6	1810	1	<10	18	<0.1	0.82	2.2	67.7
Imperial Valley J22	I-IV-J22B	65.3	603	2.1	<10	7.1	<0.1	0.9	1	67
Imperial Valley J22	I-IV-J22C	68	343	0.91	<7	4.8	<0.1	0.45	0.6	69.8
Imperial Valley J22	I-IV-J22D	65.4	851	<0.6	37	14	<0.1	0.8	1.7	208
Imperial Valley J22	I-IV-J22E	59.6	1020	0.81	10	12	<0.1	0.45	1.7	32.9
Imperial Valley K18	I-IV-K18A	69.5	1220	0.75	6	10	<0.1	0.5	1.5	48.6
Imperial Valley K18	I-IV-K18B	70.6	1540	0.5	<7	14	<0.1	1.1	2.8	78.8
Imperial Valley K18	I-IV-K18C	68	1250	0.3	<7	13	<0.1	1	2.8	50.3
Imperial Valley K18	I-IV-K18D	63.8	1190	<0.5	<10	12	<0.1	0.65	2.4	38
Imperial Valley K18	I-IV-K18E	64.4	1520	0.3	<7	15	<0.1	0.68	2.5	26
Sonny Bono NWR	I-SB-420A	65.1	2200	0.8	<7	19	<0.1	<0.1	1.6	24
Sonny Bono NWR	I-SB-420B	70.8	1810	0.6	<4	13	<0.1	0.51	1	49.3
Sonny Bono NWR	I-SB-420C	65.8	2270	0.96	10	16	<0.1	0.43	1.8	32
Sonny Bono NWR	I-SB-420D	68.4	4970	1.1	<8	33.8	<0.1	0.72	3.7	37
Sonny Bono NWR	I-SB-420E	54.1	24500	4.5	18	137	0.56	1.2	19	63.7
Kern NWR	I-K-15A	62.4	1230	0.88	<6	68.7	<0.1	1.2	1.7	102
Kern NWR	I-K-15B	53.7	1970	0.5	8	41.9	<0.1	1	2.2	51.3
Kern NWR	I-K-15C	59.6	855	2.3	10	22.7	<0.1	0.6	1	31
Kern NWR	I-K-15D	55.2	2010	<0.6	<20	16	<0.1	0.97	2.2	59
Kern NWR	I-K-15E	54.4	1860	0.5	10	50.4	<0.1	0.81	2.7	56

Appendix 4. cont.

Location	Sample	Fe ug/g dw	Mg ug/g dw	Mn ug/g dw	Mo ug/g dw	Ni ug/g dw	Pb ug/g dw	Se ug/g dw	Sr ug/g dw	V ug/g dw	Zn ug/g dw
Imperial Valley J20	I-IV-J20A	170	1270	29	3	0.6	<0.8	1.4	9.8	0.8	194
Imperial Valley J20	I-IV-J20B	2160	3300	68	<2	2.4	7.2	3	301	6.1	592
Imperial Valley J20	I-IV-J20C	374	1720	22	<2	0.9	<2	2.8	15	1	468
Imperial Valley J20	I-IV-J20D	686	1930	35	<2	1	<1	2	20.8	1.8	409
Imperial Valley J20	I-IV-J20E	160	1360	13	<2	1	<2	2.7	9	<0.5	401
Imperial Valley J22	I-IV-J22A	1220	2230	49	<2	1.8	<1	2.2	32.7	3.3	640
Imperial Valley J22	I-IV-J22B	458	2060	42	<2	1.5	<1	3	23.2	1	446
Imperial Valley J22	I-IV-J22C	298	1850	25	<2	<0.5	<0.7	3.4	20	0.7	491
Imperial Valley J22	I-IV-J22D	673	1770	40	6	1.5	<1	4.4	29	3.2	747
Imperial Valley J22	I-IV-J22E	745	1400	27	<2	0.9	<0.5	1.6	23.2	2.2	427
Imperial Valley K18	I-IV-K18A	772	1860	50	<2	1	<0.6	1.3	24	2.2	420
Imperial Valley K18	I-IV-K18B	922	2280	49	<2	1	2	1.5	28	3.2	606
Imperial Valley K18	I-IV-K18C	822	2000	49	<2	<0.5	<0.7	1.1	24	2.8	359
Imperial Valley K18	I-IV-K18D	755	1720	36	<2	<0.5	<1	1.6	22.3	2.3	368
Imperial Valley K18	I-IV-K18E	891	1700	35	<2	0.5	<0.7	0.93	38.8	2.9	273
Sonny Bono NWR	I-SB-420A	1700	2090	48	<2	1.9	1	0.78	27.3	4.7	171
Sonny Bono NWR	I-SB-420B	1260	2280	46	2	1.7	1	1	27	3.4	215
Sonny Bono NWR	I-SB-420C	1580	2230	51.8	<2	1.5	1	1.3	30.1	4.4	206
Sonny Bono NWR	I-SB-420D	3240	4040	86.9	2	3.3	2.6	1.1	46.6	8.9	176
Sonny Bono NWR	I-SB-420E	12300	7880	226	<2	11	11	2.8	298	36	138
Kern NWR	I-K-15A	1160	2630	34	<2	2.4	<0.6	0.63	413	3.3	160
Kern NWR	I-K-15B	1970	2750	64.2	2	2.7	<0.8	0.5	259	5.1	140
Kern NWR	I-K-15C	909	2330	36	<2	2.2	<0.8	0.5	127	2.7	118
Kern NWR	I-K-15D	1950	2300	55.5	<2	2.6	<2	0.5	43.4	5.4	164
Kern NWR	I-K-15E	1840	2430	59.9	<2	2.6	1	0.91	217	4.5	213

*Mercury not detected in any of the terrestrial invertebrate samples.

Appendix 5. Concentrations of organic pesticides* and trifluralin (ng/g dry weight) in terrestrial invertebrate samples collected from mountain plover wintering sites in California, 2006.

Location	Sample	Moisture %	beta BHC ng/g dw	dieldrin ng/g dw	endosulfan II ng/g dw	endrin ng/g dw	gamma chlordane ng/g dw	HCB ug/g dw
Imperial Valley J20	I-IV-J20A	58.1	<8.52	<8.52	<8.52	<8.52	<8.52	<8.52
Imperial Valley J20	I-IV-J20B	58.5	<8.03	23.4	30.5	126	<8.03	<8.03
Imperial Valley J20	I-IV-J20C	56.8	<16.5	<16.5	<16.5	<16.5	<16.5	<16.5
Imperial Valley J20	I-IV-J20D	61.8	<16.4	<16.4	<16.4	<16.4	<16.4	<16.4
Imperial Valley J20	I-IV-J20E	57.4	<23.5	<23.5	<23.5	<23.5	<23.5	<23.5
Imperial Valley J22	I-IV-J22A	62.5	<16.7	<16.7	<16.7	<16.7	<16.7	<16.7
Imperial Valley J22	I-IV-J22B	68.5	<11.4	<11.4	<11.4	<11.4	<11.4	<11.4
Imperial Valley J22	I-IV-J22C	64.5	<5.22	<5.22	<5.22	<5.22	<5.22	7.91
Imperial Valley J22	I-IV-J22D	69.5	<10.9	<10.9	<10.9	<10.9	<10.9	<10.9
Imperial Valley J22	I-IV-J22E	55.6	<10.2	28.1	<10.2	31.5	<10.2	<10.2
Imperial Valley K18	I-IV-K18A**	71.6	<4.29	32.8	11.1	21.1	<4.29	<4.29
Imperial Valley K18	I-IV-K18B**	68.8	<3.2	<3.2	<3.2	7.13	3.56	<3.2
Imperial Valley K18	I-IV-K18C	69.2	<5.8	<5.8	<5.8	<5.8	<5.8	<5.8
Imperial Valley K18	I-IV-K18D	63.5	4.22	<4.03	<4.03	9.6	6.84	<4.03
Imperial Valley K18	I-IV-K18E**	61.3	<3.01	<3.01	<3.01	11.7	<3.01	<3.01
Sonny Bono NWR	I-SB-420A**	66.3	<3.71	<3.71	<3.71	<3.71	<3.71	<3.71
Sonny Bono NWR	I-SB-420B	70.4	<7.03	<7.03	<7.03	<7.03	<7.03	<7.03
Sonny Bono NWR	I-SB-420C	64.9	7.86	<5.7	<5.7	8.65	<5.7	<5.7
Sonny Bono NWR	I-SB-420D	69.9	<4.37	<4.37	<4.37	4.75	<4.37	<4.37
Sonny Bono NWR	I-SB-420E**	62.5	<4.17	<4.17	<4.17	29.7	6.32	<4.17
Kern NWR	I-K-15A	62.4	<10.2	<10.2	98	1,020	<10.2	<10.2
Kern NWR	I-K-15B	52.5	<21	<21	<21	<21	<21	<21
Kern NWR	I-K-15C	59.7	<6.2	<6.2	<6.2	<6.2	<6.2	<6.2
Kern NWR	I-K-15D	55.6	<11.3	<11.3	<11.3	<11.3	<11.3	<11.3
Kern NWR	I-K-15E	52.3	<8.06	<8.06	<8.06	<8.06	<8.06	<8.06

Appendix 5. cont.

Location	Sample	oxychlordane ng/g dw	p,p'-DDE ng/g dw	p,p'-DDT ng/g dw	1,2,4,5-Tetrachlorobenzene ng/g dw	Trifluralin ng/g dw
Imperial Valley J20	I-IV-J20A	<8.52	137	<8.52	25.9	256
Imperial Valley J20	I-IV-J20B	11.6	283	<8.03	90.9	82.5
Imperial Valley J20	I-IV-J20C	<16.5	312	<16.5	42.1	58.4
Imperial Valley J20	I-IV-J20D	<16.4	401	<16.4	<16.4	<32
Imperial Valley J20	I-IV-J20E	<23.5	478	<23.5	123	78.6
Imperial Valley J22	I-IV-J22A	<16.7	222	<16.7	<16.7	49.3
Imperial Valley J22	I-IV-J22B	<11.4	342	<11.4	<11.4	<22.5
Imperial Valley J22	I-IV-J22C	<5.22	547	<5.22	50.9	32.6
Imperial Valley J22	I-IV-J22D	<10.9	1,310	<10.9	<10.9	252
Imperial Valley J22	I-IV-J22E	<10.2	1,240	<10.2	<10.2	71.8
Imperial Valley K18	I-IV-K18A	<4.29	56.6	<4.29	<4.29	51.3
Imperial Valley K18	I-IV-K18B	<3.2	54.4	<3.2	5.43	49.7
Imperial Valley K18	I-IV-K18C	<5.8	47.8	<5.8	18.8	52.4
Imperial Valley K18	I-IV-K18D	<4.03	310	<4.03	29.9	35.3
Imperial Valley K18	I-IV-K18E	<3.01	130	<3.01	<3.01	157
Sonny Bono NWR	I-SB-420A	<3.71	142	<3.71	<3.71	9.13
Sonny Bono NWR	I-SB-420B	<7.03	225	<7.03	21.4	<14.4
Sonny Bono NWR	I-SB-420C	<5.7	259	<5.7	27.9	<11.3
Sonny Bono NWR	I-SB-420D	<4.37	358	10.9	<4.37	<8.78
Sonny Bono NWR	I-SB-420E	<4.17	547	19.5	<4.17	<8.33
Kern NWR	I-K-15A	<10.2	14.4	<10.2	21.4	<20.9
Kern NWR	I-K-15B	<21	<21	<21	<21	<44.8
Kern NWR	I-K-15C	<6.2	<6.2	<6.2	8.93	<12.2
Kern NWR	I-K-15D	<11.3	<11.3	<11.3	14.7	<22.3
Kern NWR	I-K-15E	<8.06	17.2	<8.06	<8.06	<16.1

Appendix 5. cont.

*Aldrin, alpha BHC, alpha chlordane, chlorpyrifos, cis-nonachlor, delta BHC, gamma BHC, heptachlor, heptachlor epoxide, mirex, o,p'-DDD, o,p'-DDE, o,p'-DDT, p,p'-DDD, pentachloro- anisole, toxaphene, trans-nonachlor, and 1,2,3,4-tetrachlorobenzene were analyzed for in all samples but were not detected.

** The following organophosphates aldicarb, azinphos-methyl, barban, bendiocarb, carbaryl, carbofuran, coumaphos demeton, diazinon, dichlorvos/naled, dimethoate, disulfoton, EPN, ethoprop, fensulfothion, fenthion, malathion, merphos/tribufos, methiocarb, methomyl, methyl parathion, mevinphos, monocrotophos, naled, oxamyl, parathion, phorate, propham, protothiofos, ronnel, sulfotepp, sulprofos, tetrachlorvinphos, tetraethylpyrophosphate, trichloronate were analyzed for in these five terrestrial invertebrate samples but were not detected.

Appendix 6. Concentrations of PCBs* (ng/g dry weight) in terrestrial invertebrate samples collected from mountain plover wintering sites in California, 2006.

Location	Sample	Moisture %	Cl4-PCB ng/g dw	Cl5-PCB ng/g dw	Cl6-PCB ng/g dw	PCB# 1 ng/g dw	PCB# 105 ng/g dw	PCB# 107 ng/g dw
Imperial Valley J20	I-IV-J20A	58.1	<170	<170	<170	<1.7	<1.7	<1.7
Imperial Valley J20	I-IV-J20B	58.5	314	306	<161	<1.61	<1.61	36.8
Imperial Valley J20	I-IV-J20C	56.8	<331	<331	<331	<3.31	<3.31	<3.31
Imperial Valley J20	I-IV-J20D	61.8	<328	<328	<328	<3.28	<3.28	<3.28
Imperial Valley J20	I-IV-J20E	57.4	<469	<469	<469	<4.69	<4.69	<4.69
Imperial Valley J22	I-IV-J22A	62.5	<333	<333	<333	<3.33	<3.33	<3.33
Imperial Valley J22	I-IV-J22B	68.5	<227	<227	<227	<2.27	<2.27	<2.27
Imperial Valley J22	I-IV-J22C	64.5	<104	<104	<104	<1.04	<1.04	<1.04
Imperial Valley J22	I-IV-J22D	69.5	<218	<218	<218	<2.18	<2.18	<2.18
Imperial Valley J22	I-IV-J22E	55.6	<205	<205	<205	<2.05	<2.05	<2.05
Imperial Valley K18	I-IV-K18A	71.6	<85.8	<85.8	<85.8	<0.858	<0.858	<0.858
Imperial Valley K18	I-IV-K18B	68.8	<64	<64	<64	<0.64	<0.64	<0.64
Imperial Valley K18	I-IV-K18C	69.2	<116	<116	<116	<1.16	<1.16	<1.16
Imperial Valley K18	I-IV-K18D	63.5	<80.6	<80.6	<80.6	<0.806	<0.806	<0.806
Imperial Valley K18	I-IV-K18E	61.3	<60.1	<60.1	<60.1	14.4	<0.601	<0.601
Sonny Bono NWR	I-SB-420A	66.3	<74.1	<74.1	<74.1	<0.741	<0.741	<0.741
Sonny Bono NWR	I-SB-420B	70.4	<141	<141	<141	<1.41	<1.41	<1.41
Sonny Bono NWR	I-SB-420C	64.9	<114	<114	<114	<1.14	<1.14	<1.14
Sonny Bono NWR	I-SB-420D	69.9	<87.3	<87.3	<87.3	<0.873	<0.873	<0.873
Sonny Bono NWR	I-SB-420E	62.5	<83.3	<83.3	<83.3	<0.833	5.57	<0.833
Kern NWR	I-K-15A	62.4	<204	<204	301	<2.04	<2.04	<2.04
Kern NWR	I-K-15B	52.5	<421	<421	<421	<4.21	<4.21	<4.21
Kern NWR	I-K-15C	59.7	<124	<124	<124	<1.24	<1.24	<1.24
Kern NWR	I-K-15D	55.6	<225	<225	<225	<2.25	<2.25	<2.25
Kern NWR	I-K-15E	52.3	<161	<161	<161	<1.61	<1.61	<1.61

Appendix 6. cont.

Location	Sample	PCB# 119 ng/g dw	PCB# 135 ng/g dw	PCB# 138/160 ng/g dw	PCB# 141/179 ng/g dw	PCB# 149/123 ng/g dw	PCB# 151 ng/g dw	PCB# 172 ng/g dw
Imperial Valley J20	I-IV-J20A	<1.7	<1.7	13	<1.7	<1.7	<1.7	<1.7
Imperial Valley J20	I-IV-J20B	<1.61	24.5	8.62	31.2	3.84	43.9	2.26
Imperial Valley J20	I-IV-J20C	<3.31	<3.31	20.1	<3.31	<3.31	<3.31	8.55
Imperial Valley J20	I-IV-J20D	<3.28	<3.28	18.3	<3.28	<3.28	<3.28	12
Imperial Valley J20	I-IV-J20E	<4.69	<4.69	26.2	<4.69	<4.69	<4.69	11.2
Imperial Valley J22	I-IV-J22A	<3.33	<3.33	23.8	<3.33	<3.33	<3.33	22
Imperial Valley J22	I-IV-J22B	<2.27	<2.27	21	<2.27	<2.27	<2.27	14.3
Imperial Valley J22	I-IV-J22C	<1.04	<1.04	7.66	<1.04	<1.04	<1.04	5.09
Imperial Valley J22	I-IV-J22D	<2.18	<2.18	15	<2.18	<2.18	<2.18	14
Imperial Valley J22	I-IV-J22E	<2.05	<2.05	19.1	<2.05	6.97	<2.05	21.5
Imperial Valley K18	I-IV-K18A	1.38	<0.858	5.74	11.3	<0.858	<0.858	5.19
Imperial Valley K18	I-IV-K18B	<0.64	<0.64	6.63	<0.64	<0.64	<0.64	5.05
Imperial Valley K18	I-IV-K18C	<1.16	<1.16	7.06	16.4	1.16	<1.16	7.13
Imperial Valley K18	I-IV-K18D	<0.806	<0.806	8.54	<0.806	<0.806	<0.806	6.95
Imperial Valley K18	I-IV-K18E	<0.601	<0.601	4.53	<0.601	<0.601	<0.601	2.19
Sonny Bono NWR	I-SB-420A	<0.741	<0.741	5.19	<0.741	<0.741	<0.741	2.56
Sonny Bono NWR	I-SB-420B	<1.41	<1.41	8.36	<1.41	<1.41	<1.41	6.19
Sonny Bono NWR	I-SB-420C	<1.14	<1.14	7.29	6.86	<1.14	<1.14	4.23
Sonny Bono NWR	I-SB-420D	<0.873	<0.873	8.19	3.28	<0.873	<0.873	6.03
Sonny Bono NWR	I-SB-420E	7.38	<0.833	5.18	3.12	<0.833	<0.833	3.19
Kern NWR	I-K-15A	<2.04	193	16.8	<2.04	<2.04	90.4	8.95
Kern NWR	I-K-15B	<4.21	<4.21	<4.21	<4.21	<4.21	<4.21	<4.21
Kern NWR	I-K-15C	<1.24	<1.24	7.13	<1.24	<1.24	<1.24	<1.24
Kern NWR	I-K-15D	<2.25	<2.25	20.7	<2.25	<2.25	<2.25	<2.25
Kern NWR	I-K-15E	<1.61	<1.61	11.2	<1.61	<1.61	<1.61	4.21

Appendix 6. cont.

Location	Sample	PCB# 175 ng/g dw	PCB# 177 ng/g dw	PCB# 180 ng/g dw	PCB# 193 ng/g dw	PCB# 196 ng/g dw	PCB# 197 ng/g dw	PCB# 206 ng/g dw
Imperial Valley J20	I-IV-J20A	10.7	<1.7	3.41	<1.7	<1.7	<1.7	<1.7
Imperial Valley J20	I-IV-J20B	10.6	24.5	3.06	6.48	<1.61	<1.61	<1.61
Imperial Valley J20	I-IV-J20C	23.5	<3.31	3.63	<3.31	<3.31	<3.31	<3.31
Imperial Valley J20	I-IV-J20D	24.1	<3.28	5.73	<3.28	<3.28	<3.28	<3.28
Imperial Valley J20	I-IV-J20E	32.1	<4.69	11.7	<4.69	<4.69	<4.69	<4.69
Imperial Valley J22	I-IV-J22A	28.7	<3.33	<3.33	<3.33	<3.33	<3.33	<3.33
Imperial Valley J22	I-IV-J22B	18.3	<2.27	<2.27	<2.27	<2.27	<2.27	<2.27
Imperial Valley J22	I-IV-J22C	7.57	<1.04	3.65	4.06	<1.04	<1.04	<1.04
Imperial Valley J22	I-IV-J22D	16.9	<2.18	<2.18	<2.18	<2.18	<2.18	<2.18
Imperial Valley J22	I-IV-J22E	12.4	<2.05	8.35	<2.05	<2.05	<2.05	<2.05
Imperial Valley K18	I-IV-K18A	5.52	4.5	1.18	<0.858	3.46	<0.858	<0.858
Imperial Valley K18	I-IV-K18B	3.4	<0.64	1.23	<0.64	3.91	<0.64	<0.64
Imperial Valley K18	I-IV-K18C	7.8	<1.16	2.5	<1.16	3.6	<1.16	<1.16
Imperial Valley K18	I-IV-K18D	4.69	<0.806	2.3	<0.806	4.3	4.01	<0.806
Imperial Valley K18	I-IV-K18E	1.77	<0.601	0.633	<0.601	1.26	<0.601	<0.601
Sonny Bono NWR	I-SB-420A	4.52	<0.741	1.72	<0.741	<0.741	<0.741	3.66
Sonny Bono NWR	I-SB-420B	8.8	<1.41	<1.41	<1.41	<1.41	<1.41	<1.41
Sonny Bono NWR	I-SB-420C	6.82	<1.14	2.94	<1.14	<1.14	<1.14	<1.14
Sonny Bono NWR	I-SB-420D	5.05	<0.873	<0.873	<0.873	<0.873	<0.873	<0.873
Sonny Bono NWR	I-SB-420E	5.05	<0.833	<0.833	<0.833	<0.833	<0.833	<0.833
Kern NWR	I-K-15A	17	193	3.67	<2.04	<2.04	<2.04	<1.41
Kern NWR	I-K-15B	22.7	<4.21	<4.21	<4.21	<4.21	<4.21	<1.14
Kern NWR	I-K-15C	7.77	<1.24	<1.24	<1.24	<1.24	<1.24	<0.873
Kern NWR	I-K-15D	13.5	<2.25	6.55	<2.25	<2.25	<2.25	<0.833
Kern NWR	I-K-15E	9.81	<1.61	4.26	<1.61	<1.61	<1.61	<1.61

Appendix 6. cont.

Location	Sample	PCB# 207 ng/g dw	PCB# 209 ng/g dw	PCB# 28 ng/g dw	PCB# 31 ng/g dw	PCB# 41/64 ng/g dw	PCB# 47/75 ng/g dw	PCB# 49 ng/g dw
Imperial Valley J20	I-IV-J20A	<1.7	<1.7	9.35	<1.7	<1.7	<1.7	<1.7
Imperial Valley J20	I-IV-J20B	<1.61	4.08	8.76	<1.61	<1.61	<1.61	<1.61
Imperial Valley J20	I-IV-J20C	<3.31	11.9	12.6	<3.31	<3.31	<3.31	<3.31
Imperial Valley J20	I-IV-J20D	<3.28	<3.28	10.4	<3.28	<3.28	<3.28	<3.28
Imperial Valley J20	I-IV-J20E	<4.69	<4.69	20.8	<4.69	<4.69	<4.69	<4.69
Imperial Valley J22	I-IV-J22A	<3.33	<3.33	34.1	<3.33	4.39	<3.33	<3.33
Imperial Valley J22	I-IV-J22B	<2.27	<2.27	16	<2.27	8.98	<2.27	<2.27
Imperial Valley J22	I-IV-J22C	<1.04	<1.04	11.6	1.12	2.34	<1.04	<1.04
Imperial Valley J22	I-IV-J22D	<2.18	<2.18	14.7	<2.18	<2.18	<2.18	<2.18
Imperial Valley J22	I-IV-J22E	<2.05	<2.05	13.4	<2.05	<2.05	<2.05	<2.05
Imperial Valley K18	I-IV-K18A	<0.858	<0.858	5.5	<0.858	<0.858	<0.858	<0.858
Imperial Valley K18	I-IV-K18B	<0.64	1.29	5.6	<0.64	2.81	<0.64	<0.64
Imperial Valley K18	I-IV-K18C	<1.16	1.9	6.81	<1.16	<1.16	<1.16	<1.16
Imperial Valley K18	I-IV-K18D	<0.806	2.61	5.25	<0.806	<0.806	<0.806	<0.806
Imperial Valley K18	I-IV-K18E	<0.601	2.42	4.21	<0.601	<0.601	<0.601	<0.601
Sonny Bono NWR	I-SB-420A	2.05	5.65	3.92	<0.741	<0.741	<0.741	<0.741
Sonny Bono NWR	I-SB-420B	<1.41	<1.41	7.58	<1.41	<1.41	<1.41	<1.41
Sonny Bono NWR	I-SB-420C	<1.14	<1.14	5.95	<1.14	<1.14	<1.14	<1.14
Sonny Bono NWR	I-SB-420D	<0.873	<0.873	5.78	<0.873	<0.873	<0.873	<0.873
Sonny Bono NWR	I-SB-420E	<0.833	1.19	6.4	<0.833	<0.833	<0.833	<0.833
Kern NWR	I-K-15A	<1.41	<2.04	17.1	<2.04	<2.04	<2.04	<2.04
Kern NWR	I-K-15B	<1.14	<4.21	39.8	<4.21	<4.21	<4.21	<4.21
Kern NWR	I-K-15C	<0.873	<1.24	10.5	<1.24	<1.24	59.8	13.8
Kern NWR	I-K-15D	<0.833	<2.25	26.6	<2.25	<2.25	<2.25	<2.25
Kern NWR	I-K-15E	<1.61	<1.61	16.4	<1.61	<1.61	<1.61	<1.61

Appendix 6. cont.

Location	Sample	PCB# 52 ng/g dw	PCB# 53 ng/g dw	PCB# 60/56 ng/g dw	PCB# 63 ng/g dw	PCB# 66 ng/g dw	PCB# 7/9 ng/g dw	PCB# 70 ng/g dw
Imperial Valley J20	I-IV-J20A	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
Imperial Valley J20	I-IV-J20B	<1.61	<1.61	<1.61	218	10.6	<1.61	16.2
Imperial Valley J20	I-IV-J20C	<3.31	<3.31	<3.31	<3.31	<3.31	<3.31	<3.31
Imperial Valley J20	I-IV-J20D	<3.28	<3.28	<3.28	<3.28	<3.28	<3.28	<3.28
Imperial Valley J20	I-IV-J20E	<4.69	<4.69	<4.69	<4.69	<4.69	<4.69	<4.69
Imperial Valley J22	I-IV-J22A	<3.33	<3.33	<3.33	<3.33	<3.33	<3.33	<3.33
Imperial Valley J22	I-IV-J22B	<2.27	<2.27	<2.27	<2.27	<2.27	<2.27	<2.27
Imperial Valley J22	I-IV-J22C	11.3	<1.04	<1.04	<1.04	<1.04	<1.04	<1.04
Imperial Valley J22	I-IV-J22D	<2.18	<2.18	<2.18	<2.18	<2.18	<2.18	<2.18
Imperial Valley J22	I-IV-J22E	<2.05	<2.05	<2.05	<2.05	<2.05	<2.05	<2.05
Imperial Valley K18	I-IV-K18A	<0.858	<0.858	<0.858	<0.858	5.54	<0.858	<0.858
Imperial Valley K18	I-IV-K18B	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64	<0.64
Imperial Valley K18	I-IV-K18C	<1.16	<1.16	<1.16	<1.16	<1.16	<1.16	<1.16
Imperial Valley K18	I-IV-K18D	<0.806	7.12	12	<0.806	<0.806	2.38	<0.806
Imperial Valley K18	I-IV-K18E	<0.601	<0.601	<0.601	<0.601	<0.601	<0.601	<0.601
Sonny Bono NWR	I-SB-420A	<0.741	<0.741	<0.741	<0.741	<0.741	<0.741	<0.741
Sonny Bono NWR	I-SB-420B	<1.41	<1.41	<1.41	<1.41	<1.41	<1.41	<1.41
Sonny Bono NWR	I-SB-420C	<1.14	<1.14	<1.14	<1.14	<1.14	<1.14	<1.14
Sonny Bono NWR	I-SB-420D	<0.873	<0.873	<0.873	<0.873	<0.873	<0.873	<0.873
Sonny Bono NWR	I-SB-420E	<0.833	<0.833	<0.833	9.27	<0.833	<0.833	<0.833
Kern NWR	I-K-15A	<2.04	<2.04	<2.04	<2.04	<2.04	<2.04	<2.04
Kern NWR	I-K-15B	<4.21	<4.21	<4.21	<4.21	<4.21	<4.21	<4.21
Kern NWR	I-K-15C	<1.24	<1.24	<1.24	<1.24	<1.24	<1.24	<1.24
Kern NWR	I-K-15D	<2.25	<2.25	<2.25	<2.25	<2.25	<2.25	<2.25
Kern NWR	I-K-15E	<1.61	<1.61	<1.61	<1.61	<1.61	<1.61	<1.61

Appendix 6 . cont.

Location	Sample	PCB# 72 ng/g dw	PCB# 74/61 ng/g dw	PCB# 82 ng/g dw	PCB# 84 ng/g dw	PCB# 87/115 ng/g dw	PCB# 92 ng/g dw	PCB# 95/80 ng/g dw
Imperial Valley J20	I-IV-J20A	10.7	<1.7	<1.7	<1.7	<1.7	14.4	<1.7
Imperial Valley J20	I-IV-J20B	22.2	46.7	<1.61	4.67	<1.61	4.5	<1.61
Imperial Valley J20	I-IV-J20C	26.2	<3.31	<3.31	<3.31	<3.31	<3.31	<3.31
Imperial Valley J20	I-IV-J20D	32.4	<3.28	<3.28	22.2	<3.28	5.98	<3.28
Imperial Valley J20	I-IV-J20E	<4.69	<4.69	<4.69	<4.69	<4.69	<4.69	<4.69
Imperial Valley J22	I-IV-J22A	38.7	<3.33	<3.33	<3.33	<3.33	<3.33	<3.33
Imperial Valley J22	I-IV-J22B	65.1	<2.27	<2.27	<2.27	<2.27	<2.27	<2.27
Imperial Valley J22	I-IV-J22C	37.9	<1.04	<1.04	<1.04	<1.04	<1.04	<1.04
Imperial Valley J22	I-IV-J22D	50	<2.18	<2.18	<2.18	<2.18	<2.18	<2.18
Imperial Valley J22	I-IV-J22E	<2.05	<2.05	<2.05	27.4	<2.05	36.1	<2.05
Imperial Valley K18	I-IV-K18A	4.92	<0.858	<0.858	3.78	<0.858	10.7	<0.858
Imperial Valley K18	I-IV-K18B	<0.64	<0.64	<0.64	10.1	<0.64	1.65	<0.64
Imperial Valley K18	I-IV-K18C	7.89	<1.16	<1.16	<1.16	<1.16	15.7	<1.16
Imperial Valley K18	I-IV-K18D	17	<0.806	<0.806	5.58	<0.806	1.13	<0.806
Imperial Valley K18	I-IV-K18E	9.04	<0.601	<0.601	<0.601	<0.601	<0.601	<0.601
Sonny Bono NWR	I-SB-420A	<0.741	<0.741	<0.741	<0.741	<0.741	<0.741	<0.741
Sonny Bono NWR	I-SB-420B	9.78	<1.41	<1.41	12.5	<1.41	14.8	<1.41
Sonny Bono NWR	I-SB-420C	<1.14	<1.14	<1.14	<1.14	<1.14	<1.14	<1.14
Sonny Bono NWR	I-SB-420D	22.9	<0.873	<0.873	<0.873	<0.873	5.85	<0.873
Sonny Bono NWR	I-SB-420E	<0.833	<0.833	4.7	<0.833	6.83	<0.833	3.69
Kern NWR	I-K-15A	<2.04	<2.04	<2.04	<2.04	<2.04	<2.04	<2.04
Kern NWR	I-K-15B	<4.21	<4.21	<4.21	<4.21	<4.21	<4.21	<4.21
Kern NWR	I-K-15C	<1.24	<1.24	<1.24	<1.24	<1.24	<1.24	<1.24
Kern NWR	I-K-15D	<2.25	<2.25	<2.25	<2.25	<2.25	<2.25	<2.25
Kern NWR	I-K-15E	<1.61	<1.61	<1.61	<1.61	<1.61	<1.61	<1.61

Appendix 6. cont.

Location	Sample	PCB# 99 ng/g dw	PCB-1268 ng/g dw	PCB-TOTAL ng/g dw
Imperial Valley J20	I-IV-J20A	<1.7	<170	<170
Imperial Valley J20	I-IV-J20B	260	768	768
Imperial Valley J20	I-IV-J20C	<3.31	<331	<331
Imperial Valley J20	I-IV-J20D	<3.28	<328	<328
Imperial Valley J20	I-IV-J20E	<4.69	<469	<469
Imperial Valley J22	I-IV-J22A	<3.33	<333	<333
Imperial Valley J22	I-IV-J22B	<2.27	<227	<227
Imperial Valley J22	I-IV-J22C	<1.04	<104	<104
Imperial Valley J22	I-IV-J22D	<2.18	<218	<218
Imperial Valley J22	I-IV-J22E	<2.05	<205	<205
Imperial Valley K18	I-IV-K18A	<0.858	<85.8	<85.8
Imperial Valley K18	I-IV-K18B	<0.64	<64	<64
Imperial Valley K18	I-IV-K18C	<1.16	<116	<116
Imperial Valley K18	I-IV-K18D	<0.806	86.7	86.8
Imperial Valley K18	I-IV-K18E	<0.601	<60.1	60.1
Sonny Bono NWR	I-SB-420A	<0.741	<74.1	74.1
Sonny Bono NWR	I-SB-420B	<1.41	<141	141
Sonny Bono NWR	I-SB-420C	<1.14	<114	114
Sonny Bono NWR	I-SB-420D	<0.873	<87.3	87.3
Sonny Bono NWR	I-SB-420E	33.5	95.4	95.5
Kern NWR	I-K-15A	191	605	605
Kern NWR	I-K-15B	<4.21	<421	<421
Kern NWR	I-K-15C	<1.24	<124	<124
Kern NWR	I-K-15D	<2.25	<225	<225
Kern NWR	I-K-15E	<1.61	<161	<161

Appendix 6. cont.

* Cl1# PCB, Cl10# PCB, Cl2# PCB, Cl3# PCB, Cl7# PCB, Cl8# PCB, Cl9# PCB, PCB# 101/90, PCB# 110, PCB#114, PCB# 118, PCB# 126, PCB# 128, PCB# 129, PCB# 130, PCB# 136, PCB# 146, PCB# 15, PCB# 153/132, PCB# 156, PCB# 157/173/201, PCB# 158, PCB# 16/32, PCB# 166, PCB# 167, PCB# 169, PCB# 170/190, PCB# 171/202, PCB# 174, PCB# 176/137, PCB# 178, PCB# 18/17, PCB# 183, PCB# 185, PCB# 187, PCB# 189, PCB# 191, PCB# 194, PCB# 195/208, PCB# 199, PCB# 200, PCB# 205, PCB# 22/51, PCB# 24/27, PCB# 25, PCB# 26, PCB# 29, PCB# 30, PCB# 33/20, PCB# 39, PCB# 40, PCB# 42/59/37, PCB# 44, PCB# 45, PCB# 46, PCB# 48, PCB#67, PCB#69, PCB#77, PCB# 8/5, PCB# 81, PCB# 83, PCB# 85, PCB# 97, PCB-1242, PCB-1248, PCB-1254, and PCB 1260 not detected in any terrestrial invertebrate samples.

Appendix 7. Concentrations of inorganics (ug/g dry weight) in soil samples collected from mountain plover breeding sites in Colorado, Montana, and Wyoming, 2006.

Location	**Sample**	**Ag ug/g dw**	**Al ug/g dw**	**As ug/g dw**	**B ug/g dw**	**Ba ug/g dw**	**Be ug/g dw**	**Ca ug/g dw**	**Cd ug/g dw**	**Co ug/g dw**
Pawnee National Grasslands, CO	MPPGSL01	<0.192	11200	2.26	4.08	123	0.526	6270	0.128	3.66
Charles M. Russell NWR, MT	CMRDLWLDS06	<0.194	20100	12.4	12.1	272	0.799	2830	0.31	12.6
Charles M. Russell NWR, MT	CMRNMCRBWS06	<0.192	14500	9.97	9.41	115	0.626	1940	0.274	9.67
Charles M. Russell NWR, MT	CMRNSBSRS06	0.258	21500	10	14.2	363	0.743	5060	1.09	23.2
Hailstone NWR, MT	HailS060506	<0.19	21100	9.47	12.5	187	0.79	4340	0.354	7.4
Lake Mason NWR, MT	LMS072606	<0.193	22700	8.18	13.9	206	0.988	27900	0.392	8.27
Antelope Coal Mine, WY	MPAMSL01	<0.196	11100	5.32	<1.96	148	0.972	6000	0.394	8.15
Foote Creek Rim, WY	MPFCSL01	<0.193	11500	4.66	4.96	101	0.441	4230	0.27	6.69
Thunder Basin National Grasslands, WY	MPTBSL01	<0.192	4620	2.9	<1.92	88.4	0.393	1370	0.281	5

Appendix 7. cont.

Location	Sample	Cr ug/g dw	Cu ug/g dw	Fe ug/g dw	Hg ug/g dw	K ug/g dw	Mg ug/g dw	Mn ug/g dw	Mo ug/g dw	Na ug/g dw
Pawnee National Grasslands, CO	MPPGSL01	8.91	6.74	11500	0.0101	3440	3320	228	<0.960	<192
Charles M. Russell NWR, MT	CMRDLWLDS06	24	20.6	27000	0.0259	4000	5510	458	<0.97	560
Charles M. Russell NWR, MT	CMRNMCRBWS06	21.1	16.5	22400	0.0257	3160	3720	468	<0.96	536
Charles M. Russell NWR, MT	CMRNSBSRS06	25.6	18.3	24700	0.02	4810	6630	2290	<0.96	356
Hailstone NWR, MT	HailS060506	21.9	18.1	22300	0.0281	6000	6780	426	0.99	<190
Lake Mason NWR, MT	LMS072606	23	19.9	22700	0.0233	7330	9150	487	<0.96	<193
Antelope Coal Mine, WY	MPAMSL01	16.9	30	16800	0.07	2540	3120	141	<0.980	507
Foote Creek Rim, WY	MPFCSL01	22.1	22	14900	0.0142	2780	2990	288	<0.970	<193
Thunder Basin National Grasslands, WY	MPTBSL01	8.58	18.1	8700	0.0344	1280	840	97.8	<0.960	<192

Appendix 7. cont.

Location	Sample	Ni ug/g dw	P ug/g dw	Pb ug/g dw	S ug/g dw	Se ug/g dw	Sr ug/g dw	V ug/g dw	Zn ug/g dw
Pawnee National Grasslands, CO	MPPGSL01	4.97	387	7.86	108	0.143	37.8	21.5	30.3
Charles M. Russell NWR, MT	CMRDLWLDS06	23.1	638	14.3	690	0.589	51.2	65.6	78
Charles M. Russell NWR, MT	CMRNMCRBWS06	17.8	591	12.4	408	0.561	30.5	59.3	65.1
Charles M. Russell NWR, MT	CMRNSBSRS06	40.8	602	13	521	0.391	41.3	63.8	74.9
Hailstone NWR, MT	HailS060506	18	828	15.1	337	0.499	24	46.5	82.9
Lake Mason NWR, MT	LMS072606	20	863	13.6	464	0.262	109	41.1	84.9
Antelope Coal Mine, WY	MPAMSL01	16.6	402	17.1	2200	1.22	95.2	37.3	80.6
Foote Creek Rim, WY	MPFCSL01	33.7	401	8.14	305	0.204	17.9	33.4	38.1
Thunder Basin National Grasslands, WY	MPTBSL01	9.12	272	9.29	188	0.27	24.8	22.7	43.8

Appendix 8. Organochlorine pesticides,* organophosphate pesticides,** and total PCBs (ng/g dry weight) were not detected in soil samples collected from mountain plover breeding sites in Colorado, Montana, and Wyoming, 2006.

*Organochlorine pesticides analyzed for in soil samples from Colorado, Montana, and Wyoming included: alpha BHC, alpha chlordane, beta BHC, cis-nonachlor, delta BHC, dieldrin, endrin, gamma BHC, gamma chlordane, HCB, heptachlor epoxide, mirex, o,p'-DDD, o,p'-DDE, o,p'-DDT, oxychlordane, p,p'-DDD, p,p'-DDE, p,p'-DDT, PCB Total, toxaphene, and trans-nonachlor.

**Organophosphate pesticides analyzed for in soil samples from Colorado and Wyoming included: alachlor, aldicarb, azinphosmethyl, carbaryl, carbofuran, chlorpyrifos, coumaphos, demeton, diazinon, dichlorvos, dimethoate, disulfoton, ethoprop, famphur, fensulfothion, fenthion, malathion, methiocarb, methomyl, methylparathion, mevinphos, oxamyl, parathion, phorate, terbufos, 1-naphthol, aldicarb, sulfone, aldicarb sulfoxide, baygon, carbofuran 3-OH, and EPN. These pesticides were not analyzed for in soil samples from Montana.

Appendix 9. Concentrations of inorganics* (ug/g dry weight) in terrestrial invertebrate samples collected from mountain plover breeding sites in Colorado, Montana, and Wyoming, 2006.

Location	Sample	Moisture %	Al ug/g dw	As ug/g dw	B ug/g dw	Ba ug/g dw	Be ug/g dw	Ca ug/g dw	Cd ug/g dw	Co ug/g dw
Pawnee National Grasslands, CO	MPPGTI01	65.6	134	0.112	4.56	9.18	<0.0468	1440	0.226	0.468
Pawnee National Grasslands, CO	MPPGTI03	65.7	101	0.0895	3.61	6.93	<0.0486	1530	0.348	0.486
Charles M. Russell NWR, MT	CMRDLWLDI06	60.9	381	0.951	5.11	12.5	<0.0468	1600	0.439	0.835
Charles M. Russell NWR, MT	CMRNMCRBWI06	54.3	2180	2.15	6.64	42.6	0.132	2810	0.333	2.12
Charles M. Russell NWR, MT	CMRNSBSRI06	64.3	387	1.01	4.38	14.3	<0.0449	2920	0.385	0.627
Hailstone NWR, MT	HailI060506	66.2	119	0.202	18.8	11.4	<0.0452	1640	0.306	<0.452
Lake Mason NWR, MT	LMI072606	63.6	90.3	<0.178	17.8	9.68	<0.045	1870	0.221	<0.45
Antelope Coal Mine, WY	MPAMTI01	66.9	79	0.102	5.24	7.19	<0.0476	1140	0.188	0.476
Foote Creek Rim, WY	MPFCTI01	68.5	115	0.105	3.24	5.85	<0.0461	2250	0.0941	0.461
Foote Creek Rim, WY	MPFCTI04	66.7	183	0.407	4.65	11.8	<0.0457	8200	0.164	0.457
Thunder Basin National Grasslands, WY	MPTBTI03	66.5	52.8	0.0745	3.86	6.51	<0.0514	857	0.309	0.514
Thunder Basin National Grasslands, WY	MPTBTI04	67.2	114	0.212	13.1	11.5	<0.0494	1120	0.285	0.494

Appendix 9. cont.

Location	Sample	Cr ug/g dw	Cu ug/g dw	Fe ug/g dw	Hg ug/g dw	K ug/g dw	Mg ug/g dw	Mn ug/g dw	Mo ug/g dw	Na ug/g dw
Pawnee National Grasslands, CO	MPPGTI01	0.547	14.1	198	<0.0048	8150	881	15.4	<0.936	910
Pawnee National Grasslands, CO	MPPGTI03	<0.486	23.6	132	<0.0047	8870	879	12.1	<0.972	1000
Charles M. Russell NWR, MT	CMRDLWLDI06	1.69	19.8	771	0.0103	6450	1710	79.9	<0.936	2010
Charles M. Russell NWR, MT	CMRNMCRBWI06	3.71	25.5	4300	0.0166	9230	2070	165	1.03	920
Charles M. Russell NWR, MT	CMRNSBSRI06	1.52	17.1	1260	0.00659	5740	1540	71.2	<0.898	2220
Hailstone NWR, MT	HailI060506	0.565	42.3	225	0.0106	9370	1880	20.5	<0.904	1800
Lake Mason NWR, MT	LMI072606	<0.45	47.5	161	0.0121	9840	1970	15.8	1.04	1540
Antelope Coal Mine, WY	MPAMTI01	<0.476	28	163	<0.0049	9060	920	11.7	<0.953	1110
Foote Creek Rim, WY	MPFCTI01	0.702	27.8	176	<0.0048	8890	874	17.8	<0.922	700
Foote Creek Rim, WY	MPFCTI04	0.692	20.3	242	0.0068	8470	989	22.2	<0.913	661
Thunder Basin National Grasslands, WY	MPTBTI03	0.592	18.3	136	0.0067	8230	1000	14.6	<1.03	985
Thunder Basin National Grasslands, WY	MPTBTI04	0.666	25.4	358	0.0101	7940	977	20.4	<0.988	954

Appendix 9. cont.

Location	Sample	Ni ug/g dw	P ug/g dw	Pb ug/g dw	S ug/g dw	Se ug/g dw	Si ug/g dw	Sr ug/g dw	Ti ug/g dw	V ug/g dw	Zn ug/g dw
Pawnee National Grasslands, CO	MPPGTI01	0.62	5990	0.328	4240	0.678	179	6.2	9.35	<0.468	85.5
Pawnee National Grasslands, CO	MPPGTI03	<0.486	6480	0.226	4560	0.613	207	7.51	6.65	<0.486	104
Charles M. Russell NWR, MT	CMRDLWLDI06	1.64	6110	0.866	5240	1.11	NA**	10.1	12.6	1.47	168
Charles M. Russell NWR, MT	CMRNMCRBWI06	4.94	7180	3.15	4570	1.76	NA	19.2	43	7.77	147
Charles M. Russell NWR, MT	CMRNSBSRI06	1.3	5680	0.443	4980	2.56	NA	17	14.2	1.85	169
Hailstone NWR, MT	HailI060506	0.831	6740	0.263	5270	0.853	NA	27.3	4.72	<0.452	147
Lake Mason NWR, MT	LMI072606	0.916	7090	0.212	4790	0.676	NA	31	2.93	<0.45	137
Antelope Coal Mine, WY	MPAMTI01	0.829	7120	0.202	4690	0.734	150	8.16	5.93	<0.476	137
Foote Creek Rim, WY	MPFCTI01	1.12	7290	0.34	4340	0.473	155	5.82	5.98	<0.461	116
Foote Creek Rim, WY	MPFCTI04	1.66	7030	0.244	4160	0.438	199	17.8	9.79	0.588	111
Thunder Basin National Grasslands, WY	MPTBTI03	1.2	6820	0.135	4320	0.92	131	6.44	6.67	<0.514	126
Thunder Basin National Grasslands, WY	MPTBTI04	1.77	6600	0.34	4340	0.754	141	8.8	7.58	0.682	137

*Silver not detected in any terrestrial invertebrate samples.
**NA = Not analyzed.

Appendix 10. Organochlorine pesticides,* organophosphate pesticides,** and total PCBs (ng/g dry weight) were not detected in terrestrial invertebrate samples collected from mountain plover breeding sites in Colorado, Montana, and Wyoming, 2006.

*Organochlorine pesticides analyzed for in terrestrial invertebrate samples from Colorado, Montana, and Wyoming included: alpha BHC, alpha chlordane, beta BHC, cis-nonachlor, delta BHC, dieldrin, endrin, gamma BHC, gamma chlordane, HCB, heptachlor epoxide, mirex, o,p'-DDD, o,p'-DDE, o,p'-DDT, oxychlordane, p,p'-DDD, p,p'-DDE, p,p'-DDT, PCB Total, toxaphene, and trans-nonachlor.

**Organophosphate pesticides analyzed for in terrestrial invertebrate samples from Colorado and Wyoming included: alachlor, aldicarb, azinphosmethyl, carbaryl, carbofuran, chlorpyrifos, coumaphos, diazinon, dichlorvos, dimethoate, ethoprop, famphur, fensulfothion, fenthion, malathion, methiocarb, methomyl, methylparathion, mevinphos, oxamyl, parathion, phorate, terbufos, 1-naphthol, aldicarb, sulfone, aldicarb sulfoxide, baygon, carbofuran 3-OH, and EPN. These pesticides were not analyzed for in invertebrate samples from Montana.

Appendix 11. Concentrations of inorganics* (ug/g dry weight) in eggs samples collected from mountain plover breeding sites in Colorado, Montana, and Wyoming, 2006.

Location	Sample	Moisture %	Al ug/g dw	As ug/g dw	Ba ug/g dw	Ca ug/g dw	Cd ug/g dw	Cu ug/g dw	Fe ug/g dw
Pawnee National Grasslands, CO	MPWCPE01	72.1	1.47	0.0593	10.8	2850	<0.0192	2.65	104
Pawnee National Grasslands, CO	MPWCPE02	71.7	0.909	<0.0483	13.7	2680	<0.0193	2.71	105
Pawnee National Grasslands, CO	MPWCPE03	73.8	1.34	0.224	18.4	9900	<0.02	3.37	116
Pawnee National Grasslands, CO	MPWCPE04	71	0.677	0.0507	19.6	3140	<0.0188	2.23	96.3
Pawnee National Grasslands, CO	MPWCPE05	74.7	1.33	0.193	10.5	9120	0.0207	4.29	136
BLM Lands, Phillips County, MT	BLM025MPE	73.4	<0.443	0.175	7.83	4130	<0.0175	2.66	97.9
BLM Lands, Phillips County, MT	BLM081-2MPE	70.7	<0.432	<0.171	8.83	2680	<0.0171	2.8	105
BLM Lands, Phillips County, MT	BLM081MPE	70.3	0.893	<0.176	9.37	2980	<0.0176	2.77	102
BLM Lands, Phillips County, MT	BLM189MPE	70.8	<0.429	<0.17	5.75	4740	<0.017	3.33	84.9
BLM Lands, Phillips County, MT	BLMB026MPE	74.6	0.599	0.188	6.71	13400	<0.0188	3.92	126
BLM Lands, Phillips County, MT	BLMS014MPE	75.9	0.538	0.182	8.65	19200	<0.0182	4.13	125
BLM Lands, Phillips County, MT	BLMS020MPE	72.6	0.818	<0.177	9.72	4630	<0.177	2.68	102
Charles M. Russell NWR, MT	CMRNMCMPE06	74.2	1.73	<0.178	10	2510	<0.178	2.98	111
Near Antelope Coal Mine, WY	MPAMPE01	72.6	0.732	<0.0483	5.2	2800	<0.0193	2.63	103
Near Antelope Coal Mine, WY	MPAMPE02	72	1.65	0.274	13.1	14100	0.0645	3.58	115
Foote Creek Rim, WY	MPFCPE01	71.6	0.658	0.0631	4.86	4260	<0.0204	2.83	77.4
Foote Creek Rim, WY	MPFCPE02	72	0.729	0.113	4.97	5960	<0.0176	2.65	92.8
Foote Creek Rim, WY	MPFCPE03	72.1	0.619	0.0492	3.15	2750	<0.019	2.77	82.9
Foote Creek Rim, WY	MPFCPE04	74.3	1.19	0.292	5.85	13500	<0.0186	3	97.7
Foote Creek Rim, WY	MPFCPE05	73	0.909	0.0547	5.49	3020	<0.0177	2.87	90.7

Appendix 11. Cont.

Location	Sample	Hg ug/g dw	K ug/g dw	Mg ug/g dw	Mn ug/g dw	Na ug/g dw	Ni ug/g dw	P ug/g dw	Pb ug/g dw
Pawnee National Grasslands, CO	MPWCPE01	0.0514	4490	371	0.962	5380	14.4	8690	0.0593
Pawnee National Grasslands, CO	MPWCPE02	0.0365	4800	433	1.46	4610	4.06	7920	<0.0483
Pawnee National Grasslands, CO	MPWCPE03	0.0349	6310	586	1.24	5600	35	9810	0.185
Pawnee National Grasslands, CO	MPWCPE04	0.0262	5190	425	1.95	4490	1.15	8670	<0.0471
Pawnee National Grasslands, CO	MPWCPE05	0.0344	5710	590	2.14	6190	55.7	9700	<0.0487
BLM Lands, Phillips County, MT	BLM025MPE	0.0267	5340	471	1.06	5200	<0.443	8470	<0.0438
BLM Lands, Phillips County, MT	BLM081-2MPE	0.0488	5140	403	1.51	5410	<0.432	7800	<0.0428
BLM Lands, Phillips County, MT	BLM081MPE	0.0327	4700	434	1.39	5410	<0.444	7880	0.0951
BLM Lands, Phillips County, MT	BLM189MPE	0.0409	5910	448	0.671	5200	<0.429	7380	<0.0425
BLM Lands, Phillips County, MT	BLMB026MPE	0.0322	6330	742	1.26	6950	<0.475	9470	0.131
BLM Lands, Phillips County, MT	BLMS014MPE	0.0359	6350	922	2.05	7310	<0.46	10900	0.0812
BLM Lands, Phillips County, MT	BLMS020MPE	0.0252	5310	498	0.979	6020	<0.447	8220	<0.0443
Charles M. Russell NWR, MT	CMRNMCMPE06	0.0307	5480	448	1.43	5020	<0.448	8240	0.0468
Near Antelope Coal Mine, WY	MPAMPE01	0.0225	4910	480	1.2	5020	<0.483	8080	0.0501
Near Antelope Coal Mine, WY	MPAMPE02	0.0707	5420	679	2.61	5720	<0.482	10800	0.068
Foote Creek Rim, WY	MPFCPE01	0.0419	5730	484	1.08	4940	0.669	8510	<0.0509
Foote Creek Rim, WY	MPFCPE02	0.075	5240	486	1.83	5580	<0.44	7810	<0.044
Foote Creek Rim, WY	MPFCPE03	0.0505	4620	401	0.907	4520	<0.476	8290	<0.0476
Foote Creek Rim, WY	MPFCPE04	0.0518	5730	748	1.52	6570	<0.465	10300	<0.0465
Foote Creek Rim, WY	MPFCPE05	0.0385	5320	420	1.1	5150	<0.443	8150	0.046

Appendix 11. Cont.

Location	Sample	S ug/g dw	Se ug/g dw	Si ug/g dw	Sr ug/g dw	Ti ug/g dw	Zn ug/g dw
Pawnee National Grasslands, CO	MPWCPE01	5420	3.84	9.77	4.3	<0.481	48.4
Pawnee National Grasslands, CO	MPWCPE02	6740	2.66	12.9	3.81	<0.483	39.7
Pawnee National Grasslands, CO	MPWCPE03	6840	3	11.8	11.5	1.06	60
Pawnee National Grasslands, CO	MPWCPE04	5950	2.19	11.6	6.22	<0.471	55.3
Pawnee National Grasslands, CO	MPWCPE05	6520	2.75	11.9	13.5	0.946	56
BLM Lands, Phillips County, MT	BLM025MPE	7160	3.85	NA**	6.21	<0.0443	43.6
BLM Lands, Phillips County, MT	BLM081-2MPE	6840	5.15	NA	4.34	<0.432	36.9
BLM Lands, Phillips County, MT	BLM081MPE	6670	4.93	NA	5.07	<0.444	36.5
BLM Lands, Phillips County, MT	BLM189MPE	7040	4.01	NA	2.74	<0.429	43.3
BLM Lands, Phillips County, MT	BLMB026MPE	9040	5.22	NA	15.5	<0.475	52.9
BLM Lands, Phillips County, MT	BLMS014MPE	9070	7.32	NA	16.6	<0.46	51.5
BLM Lands, Phillips County, MT	BLMS020MPE	7350	3.64	NA	8.98	<0.447	52.9
Charles M. Russell NWR, MT	CMRNMCMPE06	6530	3.63	NA	6.88	<0.448	40.6
Near Antelope Coal Mine, WY	MPAMPE01	6580	3.03	10.1	4.35	<0.483	43
Near Antelope Coal Mine, WY	MPAMPE02	6610	3.67	12.9	22	2.08	64.1
Foote Creek Rim, WY	MPFCPE01	6680	2.53	8.03	5.68	<0.509	55
Foote Creek Rim, WY	MPFCPE02	7020	3.1	8.24	7.92	<0.44	44.3
Foote Creek Rim, WY	MPFCPE03	5920	2.68	9.38	3.63	<0.476	43
Foote Creek Rim, WY	MPFCPE04	7650	2.73	9.23	17.1	1.78	60.2
Foote Creek Rim, WY	MPFCPE05	6450	2.16	9.93	4.42	0.564	60

*Silver, boron, beryllium, cobalt, chromium, molybdenum, and vanadium not detected in any mountain plover egg samples.
**NA = Not analyzed.

Appendix 12. Concentrations of organic compounds[1] (ng/g dry weight[2]) in eggs samples collected from mountain plover breeding sites in Colorado, Montana, and Wyoming, 2006.

Location	Sample	Moisture %	HCB ng/g dw	oxychlordane ng/g dw	p,p'-DDE ng/g dw	p,p'-DDE ng/g ww
Pawnee National Grasslands, CO	MPWCPE01	75.4	32.5	48.8	11,800	2,900
Pawnee National Grasslands, CO	MPWCPE02	73.4	7.52	11.3	43,200	11,500
Pawnee National Grasslands, CO	MPWCPE03	72.8	14.7	18.4	9,930	2,700
Pawnee National Grasslands, CO	MPWCPE04	78.9	9.48	9.48	332	70
Pawnee National Grasslands, CO	MPWCPE05	76.5	12.8	<8.51	46.8	11
BLM Lands, Phillips County, MT	BLM025MPE	76.3	<8.44	<8.44	1,730	410
BLM Lands, Phillips County, MT	BLM081-2MPE	71	10.3	<6.9	18,600	5,400
BLM Lands, Phillips County, MT	BLM081MPE	71.6	<7.04	<7.04	10,600	3,000
BLM Lands, Phillips County, MT	BLM189MPE	73.8	<7.63	<7.63	382	100
BLM Lands, Phillips County, MT	BLMB026MPE	76.6	12.8	<8.55	303	71
BLM Lands, Phillips County, MT	BLMS014MPE	76.1	16.7	25.1	134	32
BLM Lands, Phillips County, MT	BLMS020MPE	71.6	10.6	<7.04	151	43
Charles M. Russell NWR, MT	CMRNMCMPE06	74.8	<7.94	<7.94	19.8	5
Near Antelope Coal Mine, WY	MPAMPE01	76.7	8.58	<8.58	1,160	270
Near Antelope Coal Mine, WY	MPAMPE02	77.4	<8.85	8.85	111	25
Foote Creek Rim, WY	MPFCPE01	76.2	8.4	<8.40	298	71
Foote Creek Rim, WY	MPFCPE02	78	<9.09	<9.09	4,090	900
Foote Creek Rim, WY	MPFCPE03	71.6	<7.04	<7.04	3,270	930
Foote Creek Rim, WY	MPFCPE04	77.8	<9.01	<9.01	45	10
Foote Creek Rim, WY	MPFCPE05	80.8	<10.4	<10.4	323	62

[1]alpha BHC, alpha chlordane, beta BHC, cis-nonachlor, delta BHC, dieldrin, endrin, gamma BHC, gamma chlordane, heptachlor epoxide, mirex, o,p’-DDD, o,p’-DDE, o,p’-DDT, p,p’-DDD, p,p’-DDT, toxaphene, trans –nonachlor, and total PCBs not detected in any mountain plover egg samples.

[2] wet weight (ww) results given for DDE for ease of comparison among other studys’ results in the discussion section of this report.

Appendix 13. Mountain plover egg content data from breeding sites in Colorado, Montana, and Wyoming, 2006.

Location	Sample	Whole Egg Weight (g)	Egg Contents Weight (g)	Egg Volume (cc)	Nest Status	Contents Condition	Egg Fertile	Embryo Age (days)
Pawnee National Grasslands, CO	MPWCPE01	16.1	14.3	22	Active	Fresh	Yes	8
Pawnee National Grasslands, CO	MPWCPE02	14.9	13	10	Active	Fresh	Yes	4
Pawnee National Grasslands, CO	MPWCPE03	14	12.3	16	Active	Fresh	Yes	24
Pawnee National Grasslands, CO	MPWCPE04	14.4	12.7	15.5	Active	Fresh	Yes	14
Pawnee National Grasslands, CO	MPWCPE05	13.8	11.8	15.4	Active	Fresh	Yes	17
BLM Lands, Phillips County, MT	BLM025MPE	14.56	13.04	10	Abandoned	Addled	Yes	10
BLM Lands, Phillips County, MT	BLM081-2MPE	13.96	11.75	10	Abandoned	Rotten	Unknown	Unknown
BLM Lands, Phillips County, MT	BLM081MPE	14.42	11.8	10	Abandoned	Rotten	Unknown	Unknown
BLM Lands, Phillips County, MT	BLM189MPE	12.87	10.41	10	Abandoned	Rotten	Unknown	Unknown
BLM Lands, Phillips County, MT	BLMB026MPE	13.55	11.8	11	Abandoned	Addled	Yes	15
BLM Lands, Phillips County, MT	BLMS014MPE	12.65	10.72	10	Abandoned	Addled	Yes	15
BLM Lands, Phillips County, MT	BLMS020MPE	14.48	10.49	10	Abandoned	Rotten	Unknown	Unknown
Charles M. Russell NWR, MT	CMRNMCMPE06	15.47	13.39	11	Abandoned	Fresh	*	0
Near Antelope Coal Mine, WY	MPAMPE01	14.7	13.2	15	Active	Fresh	Yes	9
Near Antelope Coal Mine, WY	MPAMPE02	13.7	11.9	13.5	Active	Fresh	Yes	25**
Foote Creek Rim, WY	MPFCPE01	13.6	11.8	17	Active	Fresh	Yes	21
Foote Creek Rim, WY	MPFCPE02	15.1	13.2	15.5	Active	Fresh	Yes	21
Foote Creek Rim, WY	MPFCPE03	14.8	11.9	18	Active	Fresh	No	0
Foote Creek Rim, WY	MPFCPE04	13.9	12.5	14	Active	Fresh	Yes	25
Foote Creek Rim, WY	MPFCPE05	15.3	13.4	17	Active	Fresh	Yes	10

*Fertility not noted

**Embryo abnormal – head was abnormally small; upper bill twisted out and up.

Appendix 14. Mountain plover egg measurement data from breeding sites in Colorado, Montana, and Wyoming, 2006.

Location	Sample	Egg Length (mm) Average of 3 measurements	Egg Width (mm) Average of 3 measurements	Dry Shell Weight (mg)	Thickness Index*
Pawnee National Grasslands, CO	MPWCPE01	38.2	29.1	1300	1.17
Pawnee National Grasslands, CO	MPWCPE02	36.2	28.3	1200	1.17
Pawnee National Grasslands, CO	MPWCPE03	37.8	28.1	1300	1.23
Pawnee National Grasslands, CO	MPWCPE04	37.7	27.8	1400	1.33
Pawnee National Grasslands, CO	MPWCPE05	36.2	27.9	1700	1.69
BLM Lands, Phillips County, MT	BLM025MPE	38.2	27.6	1150	1.09
BLM Lands, Phillips County, MT	BLM081-2MPE	38.3	28.0	1230	1.15
BLM Lands, Phillips County, MT	BLM081MPE	39.6	25.6	1310	1.3
BLM Lands, Phillips County, MT	BLM189MPE	35.3	27.9	1250	1.27
BLM Lands, Phillips County, MT	BLMB026MPE	38.8	27.2	1120	1.06
BLM Lands, Phillips County, MT	BLMS014MPE	37.3	27.4	1210	1.18
BLM Lands, Phillips County, MT	BLMS020MPE	37.4	29.8	1390	1.25
Charles M. Russell NWR, MT	CMRNMCMPE06	37.5	28.1	1280	1.22
Near Antelope Coal Mine, WY	MPAMPE01	36.4	28.7	1200	1.15
Near Antelope Coal Mine, WY	MPAMPE02	39.4	27.5	1400	1.29
Foote Creek Rim, WY	MPFCPE01	36.6	27.6	1500	1.48
Foote Creek Rim, WY	MPFCPE02	37.7	29.1	1600	1.46
Foote Creek Rim, WY	MPFCPE03	37.6	27.7	1100	1.06
Foote Creek Rim, WY	MPFCPE04	37.6	28.5	1400	1.31
Foote Creek Rim, WY	MPFCPE05	37.5	28.5	1600	1.5

* Thickness Index = eggshell weight (mg) / [length (mm) x width (mm)] (Ratcliffe 1970)

Appendix 15. Mountain plover egg thickness data from breeding sites in Colorado, Montana, and Wyoming, 2006.

Location	Sample	1st Half Eggshell Thickness (um)	2nd Eggshell Half Thickness (um)	Overall Thickness (um)	Thickness Index*
		Average of 3 measurements	Average of 3 measurements	Average Thickness	
Pawnee National Grasslands, CO	MPWCPE01	22.8	24.5	23.63	1.17
Pawnee National Grasslands, CO	MPWCPE02	25.3	22	23.63	1.17
Pawnee National Grasslands, CO	MPWCPE03	27.3	24	25.63	1.23
Pawnee National Grasslands, CO	MPWCPE04	24.3	23	23.63	1.33
Pawnee National Grasslands, CO	MPWCPE05	22.3	22.3	22.25	1.69
BLM Lands, Phillips County, MT	BLM025MPE	22	21.5	21.75	1.09
BLM Lands, Phillips County, MT	BLM081-2MPE	22.5	21.5	22	1.15
BLM Lands, Phillips County, MT	BLM081MPE	21.5	21.8	21.63	1.3
BLM Lands, Phillips County, MT	BLM189MPE	25	24.5	24.75	1.27
BLM Lands, Phillips County, MT	BLMB026MPE	23.5	21.5	22.5	1.06
BLM Lands, Phillips County, MT	BLMS014MPE	23.3	24.3	23.75	1.18
BLM Lands, Phillips County, MT	BLMS020MPE	23.8	25	24.38	1.25
Charles M. Russell NWR, MT	CMRNMCMPE06	21.5	21.3	21.38	1.22
Near Antelope Coal Mine, WY	MPAMPE01	24.8	24.5	24.6	1.15
Near Antelope Coal Mine, WY	MPAMPE02	20.3	20.5	20.38	1.29
Foote Creek Rim, WY	MPFCPE01	22.8	22.5	22.63	1.48
Foote Creek Rim, WY	MPFCPE02	23	23	23	1.46
Foote Creek Rim, WY	MPFCPE03	20.5	24.5	22.5	1.06
Foote Creek Rim, WY	MPFCPE04	23.3	21.8	22.5	1.31
Foote Creek Rim, WY	MPFCPE05	23.3	24.5	23.88	1.5

* Thickness Index = eggshell weight (mg) / [length (mm) x width (mm)] (Ratcliffe 1970)

Appendix 16. Concentrations of organic pesticides, PCBs, and trifluralin* (ng/g dry weight) in eggs samples collected from mountain plover breeding sites in Colorado and Wyoming, 2007.

Location	Sample	Moisture %	alpha BHC ng/g dw	dieldrin ng/g dw	HCB ng/g dw	heptachlor epoxide ng/g dw	o,p'-DDT ng/g dw	oxychlordane ng/g dw	p,p'-DDE ng/g dw
Pawnee National Grasslands, CO	MPWCPE06	95.2	<9.08	70.4	<9.08	20.2	35.2	26.5	1,070,000
Pawnee National Grasslands, CO	MPWCPE07	71.3	1.97	<1.47	<1.47	3.56	<1.47	9.48	2,730
Pawnee National Grasslands, CO	MPWCPE08	95.1	21.2	<9.13	<9.13	17.4	<9.13	12.9	1,230
Pawnee National Grasslands, CO	MPWCPE09	94.7	13.2	<9.27	<9.27	<9.27	<9.27	15.8	4,030
Pawnee National Grasslands, CO	MPWCPE10	94.5	<8.36	<8.36	<8.36	<8.36	<8.36	54.7	638
Foote Creek Rim, WY	MPFCPE06	71.5	<1.74	<1.74	6.23	<1.74	<1.74	9.24	262

DRY WEIGHT / FRESH WEIGHT CONVERSION FOR ADDLED EGGS WITH >75% MOISTURE = 0.325 (fw concentrations will be approximately 6x higher than wet weight concentrations for eggs with 95% moisture - assuming the high moisture content is due to the addition of rinse water)

Appendix 16. cont.

Location	Sample	1,2,3,4-Tetrachlorobenzene ng/g dw	trans-nonachlor ng/g dw	Cl4-PCB ng/g dw	Cl6-PCB ng/g dw	Cl7-PCB ng/g dw	PCB-TOTAL ng/g dw
Pawnee National Grasslands, CO	MPWCPE06	<9.08	<9.08	<182	300	<182	701
Pawnee National Grasslands, CO	MPWCPE07	<1.47	<1.47	38.1	<29.5	<29.5	48
Pawnee National Grasslands, CO	MPWCPE08	83.1	13.5	217	<183	<183	595
Pawnee National Grasslands, CO	MPWCPE09	<9.27	<9.27	202	<185	<185	251
Pawnee National Grasslands, CO	MPWCPE10	<8.36	<8.36	<167	<167	<167	<167
Foote Creek Rim, WY	MPFCPE06	<1.74	<1.74	<34.8	50.8	58.7	139

*aldrin, alpha chlordane, beta BHC, chlorpyrifos, cis-nonachlor, delta BHC, endosulfan II, endrin, gamma BHC, gamma chlordane, heptachlor, mirex, o,p'-DDD, o'p'-DDE, p,p'-DDD, p,p,'-DDT, pentachloro-anisole, toxaphene, trans-nonachor, Cl1-PCB, Cl10-PCB, Cl2-PCB, Cl3-PCB, Cl5-PCB, Cl8-PCB, Cl9-PCB, 1,2,4,5-tetrachlorobenzene, trifluralin, trifluralin #10, trifluralin #11, trifluralin #12, trifluralin #13, trifluralin #14, trifluralin #15, trifluralin #17, trifluralin #2, trifluralin #20, trifluralin #21, trifluralin #3, trifluralin #4, trifluralin #5, and trifluralin #7 not detected in any plover egg samples.

Appendix 17. Mountain plover egg content data from breeding sites in Colorado and Wyoming, 2007.

Location	Sample	Whole Egg Weight (g)	Egg Contents Weight (g)	Egg Volume (cc)	Nest Status	Contents Condition	Egg Fertile	Embryo Age (days)
Pawnee National Grasslands, CO	MPWCPE06	15.1	12.8	14	Active	Fresh	Yes	1
Pawnee National Grasslands, CO	MPWCPE07	14.5	10.8	17	Active	Fresh	No	0
Pawnee National Grasslands, CO	MPWCPE08	13.2	11.7	16	Active	Fresh	Yes	8
Pawnee National Grasslands, CO	MPWCPE09	14.8	11.4	15	Active	Fresh	Yes	7
Pawnee National Grasslands, CO	MPWCPE10	15.8	11.9	15	Active	Fresh	Yes	7
Foote Creek Rim, WY	MPFCPE06	14.7	11.8	14	Active	Fresh	No	0

Appendix 18. Mountain plover egg measurement data from breeding sites in Colorado and Wyoming, 2007.

Location	Sample	Egg Length (mm)	Egg Width (mm)	Overall Thickness (um)	Thickness Index*
		Average of 3 measurements	Average of 3 measurements	Average Thickness	
Pawnee National Grasslands, CO	MPWCPE06	37.8	28.2	23.75	1.31
Pawnee National Grasslands, CO	MPWCPE07	37.7	28.2	21.19	1.22
Pawnee National Grasslands, CO	MPWCPE08	36.4	27.1	19.38	0.913
Pawnee National Grasslands, CO	MPWCPE09	37.7	28.3	22.63	1.13
Pawnee National Grasslands, CO	MPWCPE10	38.3	29.0	21.44	1.08
Foote Creek Rim, WY	MPFCPE06	37.2	28.2	20.69	1.24

* Thickness Index = eggshell weight (mg) / [length (mm) x width (mm)] (Ratcliffe 1970)

Appendix 19. Mountain plover egg thickness data from breeding sites in Colorado and Wyoming, 2007.

Location	Sample	1st Half Eggshell Thickness (um)	2nd Eggshell Half Thickness (um)	Overall Thickness (um)	Thickness Index*
		Average of 3 measurements	Average of 3 measurements	Average Thickness	
Pawnee National Grasslands, CO	MPWCP06	24.5	23	23.75	1.31
Pawnee National Grasslands, CO	MPWCPE07	21.6	20.8	21.19	1.33
Pawnee National Grasslands, CO	MPWCPE08	18.9	19.9	19.38	0.913
Pawnee National Grasslands, CO	MPWCPE09	23.9	21.4	22.63	1.13
Pawnee National Grasslands, CO	MPWCPE10	22.4	20.5	21.44	1.08
Foote Creek Rim, WY	MPFCPE06	20.1	21.3	21.69	1.24

* Thickness Index = eggshell weight (mg) / [length (mm) x width (mm)] (Ratcliffe 1970)

Appendix 20. Concentrations of organic pesticides, PCBs, and trifluralin* (ng/g dry weight) in eggs samples collected from mountain plover breeding sites in Montana, 2008.

Location	Sample	Moisture %	alpha BHC ng/g dw	alpha chlordane ng/g dw	beta BHC ng/g dw	chlorpyrifos ng/g dw	dieldrin ng/g dw	endosulfan II ng/g dw
BLM Lands, Phillips County, MT	B148P033E1	70.8	3.68	<1.65	<1.65	<1.65	<1.65	<1.65
BLM Lands, Phillips County, MT	B41P025E1	71	4.22	<1.67	<1.67	<1.67	<1.67	<1.67
BLM Lands, Phillips County, MT	B41P050E1	69.6	2.07	<1.46	<1.46	<1.46	<1.46	<1.46
BLM Lands, Phillips County, MT	B45P009E1	71.9	2.33	<1.62	<1.62	<1.62	<1.62	<1.62
BLM Lands, Phillips County, MT	B72P017E1	64.9	2.07	1.79	<1.38	3.01	7.59	6.18
BLM Lands, Phillips County, MT	S1001E1	71.5	<1.72	<1.72	<1.72	3.15	5.33	<1.72
BLM Lands, Phillips County, MT	S10P001E1	66.1	<1.54	<1.54	1.43	10.4	130	<1.54
BLM Lands, Phillips County, MT	S10P001E2	71.2	<1.59	<1.59	1.28	12.8	125	<1.59

Appendix 20. cont.

Location	Sample	endrin ng/g dw	gamma chlordane ng/g dw	HCB ng/g dw	heptachlor ng/g dw	heptachlor epoxide ng/g dw	mirex ng/g dw	o,p'-DDD ng/g dw
BLM Lands, Phillips County, MT	B148P033E1	<1.65	<1.65	14.4	<1.65	<1.65	2.04	<1.65
BLM Lands, Phillips County, MT	B41P025E1	<1.67	<1.67	6.58	<1.67	<1.67	<1.67	<1.67
BLM Lands, Phillips County, MT	B41P050E1	<1.46	<1.46	4.43	<1.46	<1.46	<1.46	<1.46
4BLM Lands, Phillips County, MT	B45P009E1	<1.62	<1.62	6.46	2.63	<1.62	<1.62	<1.62
BLM Lands, Phillips County, MT	B72P017E1	3.53	<1.38	5.93	<1.38	<1.38	<1.38	2.44
BLM Lands, Phillips County, MT	S1001E1	1.84	<1.72	7.84	<1.72	<1.72	<1.72	<1.72
BLM Lands, Phillips County, MT	S10P001E1	88.5	2.5	32.4	<1.54	9.84	12.6	<1.54
BLM Lands, Phillips County, MT	S10P001E2	139	<1.59	19.8	<1.59	15.4	4.43	<1.59

Appendix 20. cont.

Location	Sample	o,p'-DDE ng/g dw	o,p'-DDT ng/g dw	oxychlordane ng/g dw	p,p'-DDD ng/g dw	p,p'-DDE ng/g dw	p,p'-DDT ng/g dw	pentachloro-anisole ng/g dw
BLM Lands, Phillips County, MT	B148P033E1	<1.65	<1.65	7.69	<1.65	110	<1.65	<1.65
BLM Lands, Phillips County, MT	B41P025E1	<1.67	<1.67	<1.67	<1.67	<1.67	<1.67	1.72
BLM Lands, Phillips County, MT	B41P050E1	<1.46	<1.46	1.79	<1.46	220	<1.46	1.52
BLM Lands, Phillips County, MT	B45P009E1	<1.62	<1.62	<1.62	<1.62	58.2	<1.62	3.54
BLM Lands, Phillips County, MT	B72P017E1	<1.38	<1.38	<1.38	<1.38	16.4	3.3	<1.38
BLM Lands, Phillips County, MT	S1001E1	<1.72	<1.72	111	2.64	261	<1.72	<1.72
BLM Lands, Phillips County, MT	S10P001E1	33.2	<1.54	18.7	320	140,000	57.6	<1.54
BLM Lands, Phillips County, MT	S10P001E2	<1.59	6.67	10.1	300	185,000	26	2.31

Appendix 20. cont.

Location	Sample	1,2,3,4-Tetrachloro-benzene ng/g dw	1,2,4,5-Tetrachloro-benzene ng/g dw	trans-nonachlor ng/g dw	Cl4-PCB ng/g dw	Cl5-PCB ng/g dw	Cl6-PCB ng/g dw	Cl7-PCB ng/g dw	PCB TOTAL ng/g dw
BLM Lands, Phillips County, MT	B148P033E1	<1.65	15.7	<1.65	<32.9	43	<32.9	389	477
BLM Lands, Phillips County, MT	B41P025E1	<1.67	<1.67	<1.67	<33.5	42.4	<33.5	365	424
BLM Lands, Phillips County, MT	B41P050E1	7.59	19.3	<1.46	<29.1	41.2	<29.1	413	490
BLM Lands, Phillips County, MT	B45P009E1	9.38	<1.62	<1.62	<32.4	<32.4	<32.4	<32.4	75.9
BLM Lands, Phillips County, MT	B72P017E1	<1.38	20.4	<1.38	<27.7	28	<27.7	<27.7	96.9
BLM Lands, Phillips County, MT	S1001E1	<1.72	<1.72	<1.72	<34.4	<34.4	39.4	<34.4	83.8
BLM Lands, Phillips County, MT	S10P001E1	8.87	<1.54	2.99	133	225	517	188	1,110
BLM Lands, Phillips County, MT	S10P001E2	6.17	<1.59	<1.59	66	2,020	459	193	2,760

*aldrin, cis-nonachlor, delta BHC, gamma BHC, toxaphene, Cl1-PCB, Cl10-PCB, Cl2-PCB, Cl3-PCB, Cl8-PCB, Cl9-PCB, trifluralin, trifluralin #10, trifluralin #11, trifluralin #12, trifluralin #13, trifluralin #14, trifluralin #15, trifluralin #17, trifluralin #2, trifluralin #20, trifluralin #21, trifluralin #3, trifluralin #4, trifluralin #5, and trifluralin #7 not detected in any plover egg samples.

Appendix 21. Mountain plover egg content data from breeding sites in Montana, 2008.

Location	Sample	Whole Egg Weight (g)	Egg Contents Weight (g)	Egg Volume (cc)	Nest Status	Contents Condition	Egg Fertile	Embryo Age (days)
BLM Lands, Phillips County, MT	B148P033E1	*	7.77		Abandoned	Rotten	unknown	unknown
BLM Lands, Phillips County, MT	B41P025E1	*	10.92		Abandoned	Rotten	unknown	unknown
BLM Lands, Phillips County, MT	B41P050E1	*	11		Abandoned	Rotten	unknown	unknown
BLM Lands, Phillips County, MT	B45P009E1	*	11.43		Abandoned	Rotten	unknown	unknown
BLM Lands, Phillips County, MT	B72P017E1	*	6.81		Abandoned	Rotten	unknown	unknown
BLM Lands, Phillips County, MT	S1001E1	*	**		Abandoned	Rotten	unknown	unknown
BLM Lands, Phillips County, MT	S10P001E1	*	**		Abandoned	Rotten	Yes	15
BLM Lands, Phillips County, MT	S10P001E2	*	**		Abandoned	Rotten	Yes	15

*Egg collected cracked, no measurements possible without danger of breaking the egg
**weight entered onto data sheet incorrectly

Appendix 22. Mountain plover egg measurement data from breeding sites in Montana, 2008.

Location	Sample	Egg Length (mm)	Egg Width (mm)	Overall Thickness (um)	Thickness Index+
		Average of 3 measurements	Average of 3 measurements	Average Thickness	
BLM Lands, Phillips County, MT	B148P033E1	*	*	23.125	*
BLM Lands, Phillips County, MT	B41P025E1	*	*	24	*
BLM Lands, Phillips County, MT	B41P050E1	*	*	20.375	*
BLM Lands, Phillips County, MT	B45P009E1	*	*	23.5	*
BLM Lands, Phillips County, MT	B72P017E1	*	*	19.375	*
BLM Lands, Phillips County, MT	S1001E1	*	*	21.875	*
BLM Lands, Phillips County, MT	S10P001E1	*	*	20.625	*
BLM Lands, Phillips County, MT	S10P001E2	*	*	21.75	*

+ Thickness Index = eggshell weight (mg) / [length (mm) x width (mm)] (Ratcliffe 1970)
*Egg collected cracked, no measurements possible without danger of breaking the egg

Appendix 23. Mountain plover egg thickness data from breeding sites in Montana, 2008.

Location	Sample	1st Half Eggshell Thickness (um)	2nd Eggshell Half Thickness (um)	Overall Thickness (um)	Thickness Index+
		Average of 3 measurements	Average of 3 measurements	Average Thickness	
BLM Lands, Phillips County,	B148P033E1	24	22.25	23.125	*
BLM Lands, Phillips County,	B41P025E1	24.75	23.25	24	*
BLM Lands, Phillips County,	B41P050E1	21	19.75	20.375	*
BLM Lands, Phillips County,	B45P009E1	24	23	23.5	*
BLM Lands, Phillips County,	B72P017E1	20.25	18.5	19.375	*
BLM Lands, Phillips County,	S1001E1	22	21.75	21.875	*
BLM Lands, Phillips County,	S10P001E1	20.25	21	20.625	*
BLM Lands, Phillips County,	S10P001E2	22	21.5	21.75	*

+ Thickness Index = eggshell weight (mg) / [length (mm) x width (mm)] (Ratcliffe 1970)

*Egg collected cracked, no measurements possible without danger of breaking the egg

Appendix 24. Mountain plover egg content data from breeding sites in Wyoming, 2003.

Location	Sample	Egg Contents Weight (g)	Egg Volume (cc)	Contents Condition	Egg Fertile
Albany County, WY	MPACPE01	11.2	10	Egg cracked, embryonated, early	Yes
Park County, WY	MPCDPE01	17.3	16	Egg good, embryonated, early	Yes
Park County, WY	MPCDPE02	16.2	15	Egg good, embryonated, early	Yes
Park County, WY	MPCDPE03	17.8	16	Egg rotten, embryonated, early	Yes
Park County, WY	MPCDPE04	17.9	15	Egg rotten	Unknown
Park County, WY	MPCDPE05	15.6	13	Egg rotten	Unknown
Park County, WY	MPCDPE06	16.3	14	Egg rotten	Unknown
Park County, WY	MPCDPE07	15	12	Egg cracked, embryonated, late	Yes
Shirley Basin, Carbon County, WY	MPSBPE01	9.2	11	Egg good, embryonated, late	Yes
Shirley Basin, Carbon County, WY	MPSBPE02	11.6	13	Egg good, embryonated, late	Yes
Shirley Basin, Carbon County, WY	MPSBPE03	11.2	13	Egg good, embryonated, late	Yes
Shirley Basin, Carbon County, WY	MPSBPE04	17.7	18	Egg good, embryonated, mid	Yes
Shirley Basin, Carbon County, WY	MPSBPE05	13.1	13	Egg good, infertile	No

Appendix 25. Concentrations of organic pesticides, PCBs, and trifluralin* (ng/g dry weight) in eggs samples collected from mountain plover breeding sites in Wyoming, 2003.

Location	Sample	Moisture %	alpha BHC ng/g dw	alpha chlordane ng/g dw	beta BHC ng/g dw	cis-nonachlor ng/g dw	dieldrin ng/g dw	endrin ng/g dw	HCB ng/g dw
Albany County, WY	MPACPE01	69.4	3.29	<1.54	<1.54	<1.54	<1.54	<1.54	6.26
Park County, WY	MPCDPE01	70.3	1.94	<1.59	<1.59	<1.59	<1.59	<1.59	7.33
Park County, WY	MPCDPE02	71.3	1.7	<1.61	<1.61	<1.61	17.3	<1.61	7.24
Park County, WY	MPCDPE03	70	2.35	2.11	1.96	<1.52	5.67	<1.52	6.45
Park County, WY	MPCDPE04	70	1.8	<1.62	<1.62	<1.62	6.05	<1.62	6.32
Park County, WY	MPCDPE05	65.5	<1.41	<1.41	<1.41	<1.41	31.4	<1.41	15.6
Park County, WY	MPCDPE06	67.2	<1.25	<1.25	<1.25	2.08	19.5	<1.25	8.83
Park County, WY	MPCDPE07	67.5	<1.25	<1.25	<1.25	<1.25	4.37	<1.25	6.23
Shirley Basin, Carbon County, WY	MPSBPE01	74.4	1.78	<1.7	<1.7	<1.7	<1.7	3.85	5.77
Shirley Basin, Carbon County, WY	MPSBPE02	73.1	<1.84	<1.84	<1.84	<1.84	<1.84	<1.84	5.83
Shirley Basin, Carbon County, WY	MPSBPE03	73.7	2.22	<1.78	<1.78	<1.78	<1.78	2.09	6.44
Shirley Basin, Carbon County, WY	MPSBPE04	72.5	4.45	4.06	77.5	<1.71	23.3	12.7	9.9
Shirley Basin, Carbon County, WY	MPSBPE05	70.4	2.61	<1.67	<1.67	<1.67	3.1	<1.67	4.29

Appendix 25. cont.

Location	Sample	heptachlor epoxide ng/g dw	o,p'-DDT ng/g dw	oxychlordane ng/g dw	p,p'-DDD ng/g dw	p,p'-DDE ng/g dw	p,p'-DDT ng/g dw	pentachloro-anisole ng/g dw	1,2,3,4-Tetrachloro-benzene ng/g dw
Albany County, WY	MPACPE01	2.53	<1.54	12.8	<1.54	1,960	<1.54	<1.54	<1.54
Park County, WY	MPCDPE01	14.4	<1.59	17.7	<1.59	4,810	<1.59	2.06	3.58
Park County, WY	MPCDPE02	19.6	<1.61	12.3	<1.61	10,800	<1.61	<1.61	18.4
Park County, WY	MPCDPE03	8.75	<1.52	11	<1.52	4,150	3.86	<1.52	7.92
Park County, WY	MPCDPE04	8.28	<1.62	14.4	<1.62	4,220	4.05	<1.62	8.38
Park County, WY	MPCDPE05	48	<1.41	28.5	<1.41	17,400	<1.41	<1.41	40.8
Park County, WY	MPCDPE06	26.8	<1.25	20.1	<1.25	10,000	<1.25	1.85	9.17
Park County, WY	MPCDPE07	2.37	<1.25	12.4	<1.25	2,210	<1.25	<1.25	3.63
Shirley Basin, Carbon County, WY	MPSBPE01	3.27	<1.7	6.79	<1.7	149	<1.7	<1.7	<1.7
Shirley Basin, Carbon County, WY	MPSBPE02	2.79	<1.84	6.55	<1.84	1,330	<1.84	2.49	<1.84
Shirley Basin, Carbon County, WY	MPSBPE03	2.09	<1.78	6.67	<1.78	139	<1.78	<1.78	<1.78
Shirley Basin, Carbon County, WY	MPSBPE04	6.88	8.41	24.1	31.6	292,000	3.79	<1.71	<1.71
Shirley Basin, Carbon County, WY	MPSBPE05	1.87	<1.67	10.4	<1.67	1,830	<1.67	<1.67	<1.67

Appendix 25. cont.

Location	Sample	1,2,4,5-Tetrachloro-benzene ng/g dw	trans-nonachlor ng/g dw	Cl4-PCB ng/g dw	Cl5-PCB ng/g dw	Cl6-PCB ng/g dw	Cl7-PCB ng/g dw	Cl9-PCB ng/g dw	PCB-TOTAL ng/g dw
Albany County, WY	MPACPE01	<1.54	<1.54	<30.9	<30.9	<30.9	<30.9	<30.9	53.3
Park County, WY	MPCDPE01	6.6	<1.59	73.8	<31.7	<31.7	<31.7	<31.7	139
Park County, WY	MPCDPE02	28.2	2.13	<32.2	<32.2	67.5	49.9	36.3	180
Park County, WY	MPCDPE03	11.1	<1.52	31.9	<30.3	35.9	32.3	<30.3	119
Park County, WY	MPCDPE04	12.7	<1.62	49.5	<32.3	43.9	36.4	<32.3	156
Park County, WY	MPCDPE05	61.6	2.61	<28.1	<28.1	171	134	43.5	400
Park County, WY	MPCDPE06	25.7	1.35	107	<25	74.8	65.1	<25	269
Park County, WY	MPCDPE07	<1.25	1.66	<25	<25	<25	<25	<25	51.6
Shirley Basin, Carbon County, WY	MPSBPE01	<1.7	<1.7	<33.9	<33.9	<33.9	<33.9	<33.9	<33.9
Shirley Basin, Carbon County, WY	MPSBPE02	<1.84	<1.84	<36.8	<36.8	<36.8	<36.8	<36.8	<36.8
Shirley Basin, Carbon County, WY	MPSBPE03	<1.78	<1.78	<35.5	<35.5	<35.5	<35.5	<35.5	41.4
Shirley Basin, Carbon County, WY	MPSBPE04	<1.71	3.53	39.3	45.8	154	49.9	<34.3	299
Shirley Basin, Carbon County, WY	MPSBPE05	<1.67	<1.67	<33.4	<33.4	<33.4	<33.4	<33.4	39.8

*aldrin, chlorpyrifos, delta BHC, endosulfan II, gamma BHC, gamma chlordane, heptachlor, mirex, o,p'-DDD, o'p'-DDE, toxaphene, trans-nonachor, Cl1-PCB, Cl10-PCB, Cl2-PCB, Cl3-PCB, Cl8-PCB, trifluralin, trifluralin #10, trifluralin #11, trifluralin #12, trifluralin #13, trifluralin #14, trifluralin #15, trifluralin #17, trifluralin #2, trifluralin #20, trifluralin #21, trifluralin #3, trifluralin #4, trifluralin #5, and trifluralin #7 not detected in any plover egg samples.

Appendix 26. Concentrations of organic pesticides (ng/g dry weight) in egg samples* collected from mountain plover breeding sites in Montana and Colorado, 2003

Location	Sample	Lipid %	Moisture %	o,p'-DDD ng/g dw	o,p'-DDE ng/g dw	o,p'-DDT ng/g dw	p,p'-DDD ng/g dw	p,p'-DDE ng/g dw	p,p'-DDT ng/g dw
Park County (MD2), CO	COPA0201	17.1	62.6	<13.4	<14.6	<14.6	<13.4	115,000	<13.4
Park County (HS7), CO	COPA0701	14.1	69.1	<16.2	<13.6	<13.6	<16.2	110	<16.2
Park County (MD8), CO	COPA0801	13.5	67.5	<15.4	<15.2	<15.2	<15.4	3,660	<15.4
Park County (BN9), CO	COPA0901	10.8	69.7	<16.5	<18	<18	<16.5	1,620	<16.5
Park County (BS10), CO	COPA1001	23.1	60.4	<12.6	<16.7	<16.7	<12.6	2,580	<12.6
Park County (HS12), CO	COPA1201	15.6	65.8	<14.6	<14.5	<14.5	<14.6	439	<14.6
Park County (HS14), CO	COPA1401	18.1	63.1	<13.6	<17.4	<17.4	<13.6	325	<13.6
Park County (FM20), CO	COPA2001	16.9	67.1	<15.2	<18.3	<18.3	<15.2	116	<15.2
Park County (FM3), CO	COPAM301	11.4	72.2	<18	<15.7	<15.7	<18	201	<18
Park County (HS3), CO	COPAS301	12.8	70.1	<16.7	<14	<14	<16.7	177	<16.7
South Park County, CO	COSP0100	16	65.4	<14.5	<14.7	<14.7	<14.5	636	<14.5
South Park County, CO	COSP1020	11.4	71.3	<17.4	<14.4	<14.4	<17.4	143	<17.4
South Park County, CO	COSP2700	7.96	72.7	<18.3	<15	<15	<18.3	117	<18.3
South Park County, CO	COSP3700	15.1	68.2	<15.7	<15.5	<15.5	<15.7	50.3	<15.7
South Park County, CO	COSP4100	14.9	64.2	<14	<18.9	<18.9	<14	20,500	<14
South Park County, CO	COSP4400	14.8	66	<14.7	<14.6	<14.6	<14.7	7,320	<14.7
Weld County, CO	COWE0600	14.1	65.2	<14.4	<13.6	<13.6	<14.4	8,070	<14.4
Weld County, CO	COWE2002	16.2	66.6	<15	<15.2	<15.2	<15	111	<15
Weld County, CO	COWE3702	13.5	67.8	<15.5	<18	<18	<15.5	106	<15.5
Weld County, CO	COWE5002	13.1	73.6	<18.9	<16.7	<16.7	<18.9	30.3	<18.9
Phillips County, MT	MTPH2099	14.9	69	<16.1	<16.1	<16.1	<16.1	11,100	<16.1
Phillips County, MT	MTPH3100	12.9	72.7	<18.3	<18.3	<18.3	<18.3	22	<18.3
Phillips County, MT	MTPH3799	10.1	73.7	<19	<19	<19	<19	<19	<19
Phillips County, MT	MTPH6300	12.9	71.2	<17.4	<17.4	<17.4	<17.4	2,260	<17.4

*Contents of all eggs were fresh but the fertility and age of the embryo were unknown. Eggs were not collected as part of this study and the quality of the sampling effort cannot be validated.